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INCENTIVES TO INDUSTRY FOR WATER POLLU-
TION CONTROL: POLICY CONSIDERATIONS

Abt Associates, Incorporated
Cambridge, Massachusetts

December 1967

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POLICY
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Mr. Joe Moore
Commissioner
Federal Water Pollution Control Administration
Department of the Interior
Washington, D. C.

Dear Commissioner:

We are pleased to transmit this report, Incentives to Industry for Water Pollution Abatement, which represents the findings of a research project undertaken under Contract Number 77 for the Federal Water Pollution Control Administration of the Department of the Interior. This study was conducted, and the report written by members of the staff of Abt Associates Inc. This study was very much a joint effort, with much interchange of ideas, discussion and criticism among project members. However, various individuals did have certain specific responsibilities. The project was under the overall administrative and analytical direction of Mr. Marc J. Roberts, who also contributed Chapters 1, 2, 3, and 5. Special credit should go to Mr. Edward M. Miller, who was responsible for drafts of Chapters 6, 7, 8, and 9, as well as many other contributions to the study. The other two primary staff persons on the project were Mr. Jerome M. Kaufman, who contributed Chapters 4 and 11, and Mr. Richard B. Homonoff, who was responsible for the bulk of Chapter 10. Mr. Roberts also edited and revised the report with the able assistance of Miss Ruth Westheimer and Mrs. Susan Ralston Kaye.

In addition to those already mentioned, many other individuals at Abt Associates Inc. contributed to the development of this project. Research and analysis was contributed by Mr. David Suzman, Miss E. L. Gollay and Miss Martha M. Jenkins. Mr. Richard H. Rosen was the source of many helpful suggestions. A word of gratitude is also due to our typists including Mrs. Joan E. Seville and especially Miss Alida Fish. The latter acted as secretary for the project and was essential to its smooth and timely completion. We also wish to thank the many other persons who provided support services, suggestions and encouragement, including Miss Patricia Kelsey, who did the graphic design and supervised the production of the final report.

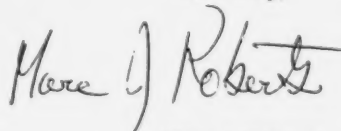
In the course of this study, comments, analysis and ideas were contributed by many individuals. Among those who were most helpful were Prof. Myron B. Fiering, Prof. Henry D. Jacoby and Prof. Richard M. Bird. Also of real assistance were Mr. Robert Ferguson, Mr. David S. Salkever, Mr. W. Gary Williams and Mr. Lawrence White.

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It should be emphasized that none of the individuals who were kind enough to assist us have any responsibility for the contents of this report. Rather, Abt Associates Inc. takes full and complete responsibility for the opinions and analysis expressed herein.

Yours truly,



Marc J. Roberts
Project Manager

incentives to industry for water pollution control: policy considerations

december, 1967

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55 Wheeler Street
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introduction

This study is an examination of alternative possible approaches for providing incentives to industry to comply with the pollution abatement standards being created under the Water Quality Act of 1965 and the Clean Water Act of 1966. The study is limited chiefly to manufacturing industry, although there are significant water pollution problems associated with aspects of mining and agriculture as well. The primary focus of the technological analysis is on the problems of organic and inorganic wastes, rather than thermal pollution. This is not to say, however, that these other areas and problems are not of vital interest to the nation's clean water program; some of the arguments developed in this report are no doubt applicable to other aspects of pollution as well.

Each of the states has already proposed standards for water quality for all inter-state waterways within its area. The Secretary of the Interior is in the process of reviewing and approving these standards. Once accepted, they will require all industrial and municipal polluters to treat their wastes before discharging them into the nation's lakes and rivers. Firms or towns that do not comply will be faced with enforcement proceedings.

When the legislation creating this system was passed, Congress expressed a desire to develop incentives to industrial polluters to comply with the standards created under the law. In recent sessions, many bills have been introduced in both Houses to provide additional assistance or incentive to industry to abate pollution. These bills have often taken the form of tax relief through accelerated depreciation or special investment credits. When the investment credit for general investment was suspended for several months recently, an exception was made for devices to abate air and water pollution. This pattern of Congressional concern is a basic aspect of the context into which the current study is being introduced.

Among industrial incentives, it proved impossible to limit consideration to only a few obvious alternatives. In addition to the more straight-forward devices like tax incentives, grants, and loans, less direct approaches were also examined, most notably the creation of treatment authorities for a whole area, river basin, or the part of such a basin within a single state. (Such a device can be considered an incentive because it significantly lowers the costs and difficulties to industry of meeting water quality standards.) In addition, it became necessary to examine the problem of possible hardship cases, and the question of whether or not the existing supply of men and material is adequate to produce and maintain the expanded amount of treatment capacity planned under the law. Also included in the report is extensive consideration of the nature of river hydrology and of some aspects of waste abatement technology. They are included because they are central to the argument made in this report that a change in the institutional structure of pollution control is necessary if the national program is to proceed in an efficient and equitable manner. Some discussion is also included of the general criteria which appear to be relevant to any discussion of incentives for pollution control. Before proceeding to the report, it is necessary to have clearly in mind some of the basic framework and analysis on which the whole structure of the argument depends.

While it is always possible to quarrel with definitions, it seems useful to distinguish "incentives" from other kinds of policy actions the government might want to undertake, most notably from "assistance." An "incentive" program is one designed to change behavior. The point of an incentive is to encourage a person to do something he would not have done otherwise. Incentives can be either positive or negative; there can be bonuses for good performance or penalties for unacceptable behavior. But the implicit focus of any "incentive" policy is on changing the current situation.

Not every kind of program the Congress might consider would be an incentive program. In fact much of the recent discussion of "incentives" to industry seems to be concerned not with the notion of incentives at all, but with programs of assistance. There is a definite distinction. Raising the pay of an involuntary draftee may be an assistance to him in some ways, but it is not an incentive for him to be drafted. An-

the distinction between incentives and assistance

other example of the distinction is provided by most of our welfare programs. Since recipients lose welfare payments when they earn income, welfare provides no incentive for them to seek employment. In fact they are a disincentive since the effort of work brings no added rewards.

The distinction between incentives and assistance is especially important in the area of water pollution control. It is easy to think of assistance plans to industry in this area which, like welfare, provide very little incentive, or even provide incentives to follow socially understandable courses of action. Suppose Congress decided to give bonuses to all firms that cleaned up their wastes, and made the benchmark from which such cleanup was measured the waste levels at some time in the future. Until the benchmark date, firms would have every incentive to dump as much waste in the stream as possible, in order to be able to receive credit for having cleaned up that much more later on.

A basic argument of this report is that many of the suggestions that have been made in Congress and elsewhere are assistance devices, and not incentives. In fact, the discussion below suggests that most tax schemes are really in the assistance category. If Congress decides that it wants to give assistance not because it will make a difference in the outcome, but because it is fair or equitable to do so, that is perfectly appropriate. But it is important that neither the legislature nor the nation confuses the two types of programs. Incentives are given because they change behavior, because society benefits from the changes they produce. Assistance is given because it seems just or fair to do so regardless of the result.

Some programs do provide incentives because they provide assistance. If you make something less costly, then perhaps more people will do it, and do it more willingly. But then the burden of proof is on the man who proposes the program. He must show why he expects his policy to make a difference. This report takes the position that such an argument can be made convincingly for river basin treatment agencies but not for other kinds of devices like tax credits.

incentives and corporate behavior

It is necessary to keep in mind that corporations are not individuals. Their officers have a legal and moral obligation to use the funds of the company to make profits for their stockholders in a wise manner. While the individuals who run and administer corporations are no doubt as moral and conscientious as any other large group of citizens, they can not consider only their personal values and tastes in making corporate decisions.

In this sense then, corporations are more rational and more carefully calculating than individual citizens. That is how they must behave in order to continue to be successful in the market. Hence it is possible to predict corporate behavior with greater precision than one can individual actions. The one generalization that seems most valid is that no responsible corporation will undertake a large loss without trying to minimize it, and then would do so only for a very good reason.

Public policy recognizes this distinction between what can be expected from individuals and what can be expected from corporations in many areas. Patriotism is perhaps one of the strongest emotions of public responsibility to which the government can appeal. Yet in wartime, while individual citizens are expected to serve at great personal sacrifice, corporations are expected to make a reasonable profit on wartime production. Even in peacetime, corporations get defense contracts while individuals get drafted. This is as it should be. Only if corporations actively seek profits will they produce what the public is most willing to pay for. But this means that one must view with some suspicion arguments that assume that the mass of corporate business will happily undertake to lose a great deal of money without trying at least to minimize the loss.

The viewpoint throughout this report is that the benefits from any program must be balanced against the costs before the program is undertaken. This is only common sense. If we refuse to strike this balance, we run the risk of making ourselves worse off because of our own lack of understanding. If it costs more to achieve a goal than the goal is worth, and we go ahead and do it anyway, we have lost rather than gained in the process.

Water is never "clean" in nature in any simple sense. Even before industrial and domestic wastes were dumped into streams, the streams were not pure. The Missouri River was known as "Big Muddy" by our ancestors long before any human activity affected its quality. Any stream in nature supports a certain amount of decaying organic matter, the remains of plants and animals that lived in the water or were washed into it. One of the most serious aspects of pollution is that it adds to the organic matter in the water. If enough of this matter is dumped into the stream, decay uses up the dissolved oxygen in the water faster than it can be replaced from the air. As the oxygen content falls, fish die; eventually the decay process changes so that the stream gives off offensive odors (see Stream Hydrology below).

The point of all this is that there is no sharp line at which a stream suddenly becomes clean, and below which it is dirty. If we balance costs and benefits, different streams will be kept at different levels of cleanliness. Cleanup costs the society real resources, and there are not enough resources to go around. Hence, a balance must be struck.

This point is especially important in light of current regulatory policy. Current policy says (more or less) that everyone will have to clean up by so much, or else. There is almost no way to balance the costs of cleaning up more or less against the change in benefits that would result. Thus to require one or a few firms on a large, clean river to install treatment capacity when the river can handle the wastes without difficulty is simply a waste of society's and the firm's resources. Perhaps in the future more firms will be built along the river and treatment will become necessary to maintain water quality. But building and operating treatment facilities is expensive and to do so sooner than is needed is a significant waste of the nation's productive capacity.

Recent events at home and abroad have demonstrated that this country is not rich enough to tolerate such waste when so many other pressing needs are demanding attention and resources. It is the responsibility of all who are concerned with effective pollution control and who desire to end the national disgrace water pollution has been in the past to proceed in an intelligent and careful manner. The national interest and the public good demand no less.

In evaluating the various policy alternatives considered in this report, it is necessary to develop some notion of how the costs of pollution abatement will be shared among different segments of society under alternative courses of action. To formulate an argument on this point it is necessary to utilize some of the models developed by formal economic theory. Use of this theory makes the next few pages among the most technical in the report. The general reader should not be discouraged if he finds them difficult: the balance of the report is less technical.

In a competitive market, economic theory tells us that in an expanding industry new firms will enter the market or old firms will build additional capacity whenever the return to the new firm or of the additional capacity exceeds alternative earnings from the capital expended. In equilibrium in the competitive model, existing firms will produce that quantity of output where marginal cost equals price and this will equal the average cost of production for the new firms entering the market. The effect of pollution control requirements will be to raise the average cost of production to the new, more efficient firm, and it will respond by charging a correspondingly higher price for its product. Thus, the cost of pollution control for the new firm, will be passed on to the consumer in the form of higher prices. In general, the costs of pollution control will be higher for the existing firm than for the new firm. There are several reasons for this.

balancing costs and benefits

who will pay for pollution control?

First, it is almost always cheaper to install treatment facilities when a plant is being constructed than after it has been built. The construction of a treatment plant will frequently require the installation of separate cooling water and waste systems, since the costs of treating the very dilute wastes that would result from mixing cooling and processing water is high. The installation costs of such a piping system in an existing plant are much greater in an old plant. Similarly, major reductions in the volume of water to be treated will result from practicing extensive recirculation of water. This is much cheaper to do when constructing a new plant than by reconstructing an old one. Moreover, new firms can set aside inexpensive land for treatment facilities and will not have to construct them on inadequate or expensive land not intended for the purpose.

Second, since there are large economies of scale in waste treatment, new firms which are also larger can take advantage of this fact where older firms might have to incur the higher per unit costs of treating wastes because they are smaller plants.

Third, for most industries, new plants produce less waste per unit of output than old plants. Thus, even if it were not less expensive for new plants to treat the same quantity of wastes as old plants, it would certainly be cheaper for them to treat the relatively smaller quantity of wastes they produce.

In light of the relative costs of pollution abatement to old and new firms, it is possible to estimate the incidence of various incentive programs to industry. In general, any subsidy will benefit the consumer to the extent that it lowers the per unit cost of pollution control to the new firm, because it is the new firm that will influence the price of the product. A subsidy given to a new firm for pollution control will lower its average cost of production and will be passed on to consumers in the form of lower prices. Equivalent subsidies given to an established firm will also lower its average cost of production, but because these costs will be higher than those for the new firm, the established firm will still have to pay for the difference in per unit costs out of profits. Thus, the established firm will retain the subsidy, rather than passing it on to the consumer in lower prices. For an industry with heavier waste loads resulting from the newer technologies, such as steel, not only will the entire subsidy go to consumers, but prices will be reduced sufficiently to transfer part of the profits to consumers as well.

Alternatively, either effluent charges or service charges, assessed on per unit waste production, will be passed on to the consumer in the form of higher prices, although established firms will still have to pay for the difference between their costs and the costs to new, more efficient firms. However, established firms will have to absorb less of the cost than if they had been required to meet minimum water quality standards, because new firms will charge the consumer the extra costs of pollution abatement. Furthermore, if service charges are administered by a basin-wide authority, then established firms will benefit from the economies of scale associated with large-scale waste treatment and their actual costs per unit of output will fall. In fact, since the average costs of processing waste would probably be lower to the basin authority than to either the old or the new firm, prices charged the consumer could fall. Again, this price reduction puts pressure on the established firm, which must support any difference between its costs and costs to newer firms out of profits.

The above argument was based on a competitive economic model. For some industries with a small number of firms such as steel or chemicals, there may be a price leadership pattern with the price leader setting prices on the basis of average costs. If pollution abatement raises average costs of the price leader, prices will probably rise less than average costs even for this case. In conclusion, given the existing pollution control policy of enforced pollution control standards, industry can be expected to pay most of the costs of pollution abatement, even though the greater part of any subsidy will accrue to industry rather than to the consumer.

summary and conclusions

The purpose of this section of the report is to present an abstract of the argument, and to summarize the conclusions reached in the report as a whole. Naturally, the complete documentation and evidence for each point cannot be adduced. Instead, the basic points are outlined and the major conclusions restated. Reading this section will provide a general knowledge of what the report says and why, without presenting in detail the evidence for its conclusions.

Following major legislation in 1965 and 1966, the nation has embarked on a systematic effort to abate water pollution. Standards are being set for each mile of interstate waterway; business firms and government units will be required to comply with these standards. Allowing for population growth, the Federal Water Pollution Control Administration has estimated that by 1973 from 11 billion dollars to 26 billion dollars will have to be spent for capital investment in waste control facilities by government and industry to meet these abatement standards. This includes an estimated 2.6 billion dollars to 4.6 billion dollars for further treatment plants to handle industrial wastes.¹

the current situation

At the moment, a wide variety of government programs are available to industry and to municipalities to help them meet waste abatement goals. Industry can already write off the depreciation generated by water pollution investment against current earnings for tax purposes. Hence the costs to industry of such investment will be only 35 percent to 45 percent of the nominal dollar value. In addition, there are a variety of research and development and demonstration grant programs producing new information which helps industry to meet waste control requirements in a more efficient and less costly manner. Also, government training grants to universities increase the number of competent personnel in pollution activities. Loans are available from the Small Business Administration and from the Economic Development Administration for certain classes of firms to help finance the costs of capital expenditures for pollution control. Finally, there is the current program of construction grants to municipalities and other government agencies for sewage treatment facilities. Recent estimates show that about one quarter of all industrial waste is currently being treated by municipal and other government treatment plants, so aid for their construction is also a significant aid to some segments of business.²

Despite all this current assistance, there is a real question as to what extent and how rapidly business will cooperate with the pollution control program. Business firms exist to make money; and pollution investment represents a significant loss to most of them. Delay in compliance is a means of forestalling or off-setting such losses. It saves the firm the operating costs it would have had to assume in the interim. Further, it allows the firm to take advantage of any technical improvements that would lower the costs of waste control which might be developed while it delays. Finally, there is always the possibility that at some future time when government funds are ample the firm would be able to take advantage of programs of government aid for pollution abatement not yet created.

On the other hand, delay can lead to undesirable results for the firm in terms of bad public relations and government hostility. There is also the possibility of enforcement action, which can ultimately compel compliance through court action. Also many executives no doubt personally believe in the desirability of pollution control and feel that their corporations have some public responsibility. The point is that in the minds of industrial decision-makers these other factors must be balanced against the often large and immediate costs of waste control, plus the significant potential cost savings of delay. To be effective, an incentive program must have some real impact on this balance of conflicting influences which currently shapes the decisions of corporate managers.

Policy-makers are faced with some basic questions about incentives. Should some kind of direct incentive be given to industry now to further pollution control? Among the alternatives, what kinds of incentives will have the most desirable direct impact and the least undesirable side effects? If direct incentives are not feasible or desir-

able, what else can be done to facilitate implementation of the nation's pollution control program? Underlying this discussion should be the realization that existing enforcement procedures do provide the "stick" behind any "carrot" that might be instituted in the form of new incentive programs. The balance of this summary chapter reviews the conclusions of this report on these and related issues.

general fiscal incentives

The type of incentive plans usually considered are based upon some general direct disbursement of funds to industry and hence can be characterized as "fiscal" incentives. Four different types of general fiscal incentives should be considered: 1. tax incentives, 2. loans, 3. grants to firms, and 4. grants to government agencies to construct facilities for treating industrial waste. The primary questions to be asked in evaluating such incentives are first, will they affect the degree and timing of pollution control actually undertaken and second, will they affect the efficiency with which such investment is made?

Consider tax incentives first. Such devices have significant and unfortunate side effects because it is difficult, if not impossible to create schemes that apply to all types of spending for pollution control. This is especially serious because operating expenditures and spending on land, which are important in some abatement techniques, are typically not included in tax incentive plans. Such tax incentives then tend to lead firms away from methods that use these inputs and toward control approaches that ultimately cost the society more in terms of real resources. In addition, tax incentives reduce the incentive for a firm to make changes in production equipment or operating processes that would lower waste loads. This is so because it does not seem feasible to give tax breaks to all general investment in new productive capacity which also happens to lower the amount of pollution produced.

In addition to these unfortunate tendencies to foster inefficiency, tax incentives also do not seem likely to encourage business firms to proceed in a more energetic manner with pollution control spending. In the magnitude usually proposed, such incentives affect the cost of abatement by only about 5 percent to 10 percent of the capital cost of some facilities, and hence affect the total cost (including operating costs) by much less. Such aid still leaves a large net loss to be absorbed by the firm which in turn leaves unaffected most of the incentives to delay discussed above. Thus, in addition to other difficulties, tax incentives seem likely to be of little help in achieving clean water, since they are unlikely to affect firm behavior.

Tax incentives, like all other types of direct assistance to firms, suffer from an additional defect. From an efficiency point of view, the prices of various goods ought to reflect the real costs of producing the merchandise concerned. However, the harmful effects that result from pollution produced during manufacture are not now reflected in final prices. Ideally, the prices of pollution-generating products should rise. Only in this way will consumers begin to take into account the full production costs in making consumption choices. It can further be argued from the standpoint of equity that the consumers of those goods which generate pollution in the courses of their production ought to be the ones to bear the costs of waste abatement. On both of these grounds, firms should not be relieved of the costs of abatement by tax incentives or other means, because if firms do not pay these costs, the prices of pollution-intensive goods will tend to rise less than they should on the basis of the above arguments.

Furthermore, tax incentives have several other serious disadvantages not shared by alternatives like loan or grant programs. First, under a tax plan the exact total amount of aid given each year is not directly controlled by Congress, nor is the program automatically reviewed annually. Hence Congress would find it difficult to adjust such incentives to changing Federal budget needs the way direct programs can be adjusted. Not only are direct programs adjustable, but also they must be reviewed each year in the appropriations process, a scrutiny the tax approach avoids. Besides being inflexible, the costs of tax schemes are also unpredictable. Under a tax incentive plan the amount of aid given depends on the amount of money

firms actually invest: this amount cannot be known for certain in advance. Thus, the Congress would be committing itself to an indeterminate amount of aid before it could know what levels of assistance would be most appropriate from an overall fiscal and budgetary point of view. Finally, tax schemes have the serious disadvantage of being biased against exactly those firms which need assistance the most. This is because the depreciation writeoffs generated by tax programs have no value to those firms without high enough profits to be able to utilize the writeoffs to lower their tax liability. Firms in difficulty thus get no aid from tax incentives.

In contrast to tax devices, direct grants to industry can, and indeed must be reconsidered each year. They can also be applied more easily to a variety of inputs like land or operating costs, and so have less disturbing effects on the efficiency of pollution abatement. But despite these advantages over tax incentives, direct industrial grants do not seem on balance to be a desirable part of the nation's pollution control program. Such grants do lower the savings a firm can make by engaging in internal process changes, which makes it less likely that they will engage in such changes. Like tax incentives, such grants also would result in lower prices for goods whose production results in pollution than would seem desirable on the basis of both equity and efficiency considerations. Further, unless such grants cover a very significant fraction of total waste control costs, they seem unlikely to alter firm behavior. In view of general budget constraints at this time, such a large program might well be neither feasible nor desirable. Finally, insofar as grants do not cover all inputs to pollution control (for example, suppose they excluded land purchase costs), they would also lower the efficiency and raise the real social opportunity costs of the nation's pollution control effort.

In evaluating loan programs, many of the same considerations that make tax incentives or direct grants inadvisable also argue against general loan programs. Such programs distort efficient choices if they do not apply to all inputs, lower the firm's incentive to engage in process change, and tend to prevent final prices from adjusting to the desired extent. However, a loan for any given amount, say \$100,000, has less distorting effects than a direct grant or tax break for the same amount since the loan has to be paid back. It also costs the government less for the same reason. Although no general program seems desirable over all, if a direct fiscal incentive plan is nevertheless adopted, loans appear to be the best choice.

One further objection to an "across-the-board" loan program is that it would have to underwrite a very high percentage of costs to alter firm behavior significantly. A more desirable alternative would be a limited loan program designed to help just those firms which would either have great difficulty raising the capital for pollution control investment or those plants which might otherwise choose to close rather than assume the costs of pollution abatement. Such a limited program, perhaps utilizing existing agencies like the Small Business Administration or the Economic Development Administration could be an effective and economical way to channel government funds to those situations where they will be most effective and most useful.

For any direct incentive program and especially for an across-the-board program (if one is adopted over the recommendations of this report), there is much to be said for limiting the program's applicability to expenditures related to existing plants, and to investment begun within a restricted period of time like three years. Owners of old plants might claim that directives to invest in abatement devices were thrust upon them. The same cannot be said of those who construct new plants and know what their responsibilities will be beforehand. Also by limiting aid to a set term of years, the incentive felt by all firms to delay is significantly reduced.

Very strong arguments also imply that municipalities should not be given federal construction grants for that portion of their facilities which are intended for the treatment of wastes from industrial plants. Instead firms should pay the agency creating the plant a reasonable service charge to cover the share of the costs of constructing and operating the treatment capacity meant for industry. Grants to municipalities that result in low service charges to industry in turn sharply lower the inducements to the firm to engage in changes in its production process to lower waste loads. Paradoxically, the result under current procedures of such aid to treatment plant construction is to make the water more polluted in the long run. Since the

treatment plants remove a given percent of waste coming in, the more that comes in, the more goes out with plant discharge. The lower the charges a municipality sets for the firm, the less waste it is economical for the firm to remove itself through process changes and better housekeeping and the more waste that winds up in the river. Thus fair service charges are essential to efficient pollution abatement. Since it is unrealistic to expect municipalities to charge industry for capital facilities that are already being financed by federal grant, the implication is that such grants should be terminated for industrial treatment capacity. There are some difficulties in deciding where to draw the line between industrial and domestic wastes. The most appropriate procedure seems to be to include large hotels and laundries in the industrial sector, but not small boarding houses and similar businesses.

implications of hydrology and technology

The physical process of pollution abatement and stream flow have significant implications for what constitutes an efficient program of waste control. One important point is that the harm done to a stream by a given amount of waste depends upon when and where that waste is dumped. This is primarily a function of the season of the year, which determines the rate of stream flow. The more water in the river, the higher its assimilative capacity and the less harm done by a given quantity of waste. Also where the stream is flowing quickly or through small rapids and waterfalls its assimilative capacity is much higher than when moving slowly.

The policy implication of this variation is that efficient waste abatement calls for a carefully designed program to utilize the assimilative capacity of the stream so as to minimize the costs of pollution control while at the same time preventing harm to fish life and to stream users. In this light seasonal scheduling of waste discharges, seasonal operation of treatment plants, and even closing some factories during critical periods should be considered vital aspects of an efficient pollution abatement program. However, such flexibility cannot be attained within the current regulatory framework.

The discussion of treatment technology makes it clear that some methods of waste treatment will be significantly less expensive than their alternatives if the proper amount of flat land is available. This means that some plants along a river will have much lower costs of waste abatement than others. In turn this implies that efficient pollution control will require different plants to treat their wastes to a different degree if stream quality is to be met at minimum costs. Like seasonal patterns, these kinds of variations too would be difficult to attain within the current administrative framework.

The technology of pollution treatment has two other important features. First, for many abatement techniques, the average costs of treating waste are less for larger plants than for smaller ones. Moreover, it is quite possible in many instances to treat industrial and domestic wastes in the same plant, provided proper precautions are taken. Finally, technical considerations show that process changes are often one of the most important alternatives for achieving efficient waste removal. Any scheme which limits the incentives to the firm to engage in such changes must be seriously suspect as a means of achieving water quality.

some criticisms of the current program

In light of the above discussion of the nature of hydrology and technology, it seems that the existing mechanism for enforcing pollution control is seriously deficient. Currently the country is insisting that every firm or government agency (with a few exceptions) treat its wastes to an equivalent level. This rule ignores the great differences in treatment costs among firms and the need to adjust abatement efforts to seasonal conditions. It presently does not seem feasible, legal or equitable to ask one man to treat a great deal while allowing his neighbor to do much less merely be-

cause the latter has lower costs when each is expected to bear the full costs only of his own treatment activity. Clearly a more flexible and efficient system of waste abatement is required if the nation is not to waste scarce resources in controlling pollution.

Because of the considerations just advanced, the report examines the advantages and strongly recommends the establishment of regional authorities which would assume much of the responsibility for waste treatment and water quality. Such authorities would vary in form and structure from place to place, depending on the political situation and the needs and physical setting of the area. The general form advocated is a single authority for each river basin. Where a basin includes several states, and an inter-state compact would be difficult to create, a reasonable alternative to a single agency would be a separate agency for that part of the basin in each different state. A given state might well go further and combine all its agencies into a single state-wide structure, but that would not be necessary to the proposed structure. The agencies proposed would assume responsibility for many existing governmental treatment plants. They would assume the debt funded to construct those plants and then finance this debt by charging municipalities for treating their sewage — leaving each town free to raise the funds to finance waste treatment as it always had. In addition, such an agency would construct treatment facilities for industry in its area. Such facilities would often be in the form of a few large plants to take advantage of the economies of scale. Industry would be charged a service charge for the treatment of their wastes based on the average costs of the authority over the whole basin or some area of it. New firms would have to pay a connection charge that would reflect the relative costs to the authority of treating wastes at different locations.

For the firm, the proposed system has several very attractive features. It relieves the firm of having to raise the capital needed to construct treatment facilities. It also relieves industrial management of the headaches and responsibilities of maintaining their own treatment facilities and living up to water quality standards. The treatment authority itself becomes responsible to another state agency and to the Federal Water Pollution Control Administration for maintaining water quality. Further, because of its ability to take advantage of economies of scale and river hydrology, the authority should be able to treat the wastes of most firms for less than it would cost them to do it themselves, thereby offering industry a major saving.

Treatment authorities would also offer many advantages to the general public. Most important they could make allowances for the very complex choices that efficient pollution abatement requires and that current institutions cannot undertake. Further, they would be able to manage the whole river system in an emergency situation like a flood or a sudden spill due to a fire or accident. They could raise the quality of treatment plant operation because their size would enable them to support expert technical services and adequate training programs. They would also be the logical agency to undertake in-stream aeration, or to participate in decisions about low-flow augmentation so as to insure that these options for maintaining water quality are efficiently integrated into the overall plan of waste control. Finally the service charges levied by such authorities maintain the incentives for the firm to engage in process changes to lower its waste load, since lower waste loads would mean lower service charges.

Under existing legislation it would be quite possible to channel existing funds for construction grants for waste treatment facilities through such river basin authorities. This policy would seem to be fitting and effective for further developing such agencies. Existing legislation could also be used to provide funds for the operating and administrative costs of such agencies in the initial period.

Advocating this approach is clearly only a beginning. While certain similar agencies already exist, both in Germany and England, and to a lesser extent in domestic institutions and agencies in metropolitan areas like Seattle, Washington, D.C., Chicago,

regional or river basin water quality authorities

and Boston, much further work needs to be done on how best to establish such a structure. Nevertheless the river basin treatment authority approach offers such tremendous possible savings to all concerned that it is worth pursuing with energy and imagination. Studies show that such an agency might attain a given level of water quality for as little as one half the costs using the current standards approach.³

effluent charges

Although they have been frequently advocated by economists concerned with this problem, effluent charges (that is, charges to firms based on what they dump into rivers) seem less efficient and practical than the kinds of river basin authorities mentioned above. The sampling and administrative costs of any effluent charge system seem likely to be very high if it is to be sophisticated enough to respond to stream hydrology and other aspects of efficient pollution abatement. In addition, such a system has none of the advantages of economies of scale, central coordination, efficient operation, and relief for firms from the burden of capital expenditures which are possessed by river basin agencies. In fact, the service charges of such agencies would have many of the favorable properties of effluent charges which have appealed to their advocates in the past, especially in that service charges would encourage firms to engage in process changes to lower their waste loads.

marginal plants and hardship cases

The problem of plants that might close rather than assume the expenses of pollution abatement is a very complex and difficult one. Such plants might close anyway in the long run, in which case financing their treatment capacity would only delay the closing a few years and leave the country with surplus and unused treatment facilities once the plant had finally shut down. It is important to realize that the indication of harm done to a plant by pollution control spending is not the absolute amount it must spend for pollution control, or even the amount spent per unit of product, or per unit value of product. The correct focus of concern is plants that will have to spend more than their rivals per unit of output, and hence whose relative costs and competitive position will be hurt by the need to invest in pollution control. Such plants are likely to be small, to use older technology, and to be in a difficult market position already. These are the same plants that might be on the way out in the long run in any case.

The key to effective policy in this area is deciding what exactly the objective of such a policy is. The position taken here is that there is no "right to pollute," and hence, because owners are not deprived of that right when they are told to clean up their wastes, they have no automatic claim to government compensation. Rather the object of concern is the unemployment that could result from closing plants in areas already depressed or which might become so once the plant in question ceases operation. If employment is the focal issue and many affected plants would be marginal in any case, then the problem is one of providing for an orderly transition and adjustment process.

There are three approaches, all of which might be used. First, regional authorities relieve marginal plants of the burden of raising a large sum of capital for treatment equipment. Since the difficulty in raising that capital may be the crucial problem for the firm, treatment agencies alone may help alleviate the difficulty to a significant degree. Second, low interest loans attack the same problem while allowing efficient allocation to prevail in the long run, since ultimately the loan is paid off and the final prices for the goods adjust. Existing agencies like the Small Business Administration and the Economic Development Administration might be utilized in this connection. Also worth considering is the third possibility, that of delaying the application of enforcement standards to the firms in question. Such a delay would allow for a more deliberate and calculated adjustment by all concerned to the changing situation.

In considering incentives to industry, one aspect examined was whether there were likely to be any chronic scarcities which would result in high prices to firms attempting to undertake pollution control expenditure or which would prevent them from accomplishing such investment all together. Three areas were investigated: material, engineers, and treatment plant operators. Investigations revealed that the first two markets are currently showing some signs of strain, in part because of the general high level of prosperity in the economy and in part because of the water pollution control program. On the material side, pollution control investment is such a small factor in the relevant markets that no action seems warranted. However, it should be borne in mind that delivery delays and some material scarcities will lead to higher costs and might produce significant delays in plant completion. Any crash program for rapid construction must be reconsidered in light of those limitations. For engineers, the problem is complex because of the possibility of other types of engineering specialists switching into sanitary engineering. Programs designed to assist and facilitate such switching, as well as efforts to modestly expand existing training programs, are worth serious consideration.

Treatment plant operators represent the greatest current supply shortage relative to demand at existing prices. Efforts to assist in the development of training facilities, and to coordinate recruitment and training programs in the area of waste control with other government training programs seems desirable. We should note that at the moment, the level of salary offered to operators by various agencies seems to be the dominant factor determining the quality and quantity of personnel the agency is able to attract. Again, river basin agencies which can support specialized personnel and effective training programs show promise for making a contribution in this area.

This study covers a great many areas. The central point it makes, however, is that the problems of effective pollution control are extremely complex. Simple administrative regulatory rules do not seem adequate to deal with the problem at hand. General incentives to firms of the sort usually considered seem unlikely to affect the amount of pollution control investment undertaken. If anything, such programs promise to raise the cost to the society of the total investment actually undertaken, because it will be done less efficiently. The answer to this complexity then is regional or river basin treatment authorities of various forms. Only this change in orientation and focus in the nation's pollution control efforts will produce abatement in an efficient and equitable manner. The cost savings involved as well as relief from the burdens of raising the capital for pollution control facilities and then having to operate them should be the most effective incentive possible to enlist the cooperation of enlightened industrial leaders in achieving an effective national program of water pollution control.

I. Fiscal Incentives

A.1 No across-the-board general fiscal incentives to industry seem to be desirable because of their adverse impact on the efficiency of pollution abatement and the small effect they seem likely to have in helping accomplish overall national water pollution control goals.

A.2 Of all the alternative incentive schemes considered, loans seem least objectionable, tax incentives the most undesirable, and direct grant programs appear to be in an intermediate position.

A.3 Any fiscal incentive scheme, either general or limited in scope, should be restricted to spending related to existing facilities and should only continue for a specific number of years, say three to five.

scarce inputs to pollution control

conclusions

summary list of specific recommendations

II. River Basin Authorities

B.1 Because they offer significant advantages and cost savings both to government and industry, every effort should be made by the Federal Government to establish river basin agencies to ultimately be responsible for all waste treatment in their areas.

B.2 Among the methods which might be used to encourage basin authorities are demonstration grant funds, grants for their administration, giving those agencies priority on construction grant funds, and efforts to educate state and local officials to the advantages of such river basin authorities.

B.3 Such basin authorities should be encouraged to take a variety of forms, depending on the particular area for which they are created. In general, however, it would be highly desirable to have the major waste sources in the region, both industrial and governmental, involved in the management and control of these agencies.

B.4 Construction grants given to basin authorities should only be intended to cover that proportion of their treatment capacity which is not intended to treat industrial wastes.

B.5 Industrial waste dischargers should pay basin authorities a service charge, based on the authorities' average costs, for treating their wastes.

III. Current Problems

C.1 The objective of regulatory action should be the impact of behavior on stream quality and not oriented toward standards of treatment considered in isolation. Thus stream standards should be explicitly formulated to allow basin authorities or any other waste sources to respond to changing river conditions through seasonal operation of treatment facilities and seasonal storage of wastes, and to undertake different levels of treatment at different locations where the costs of treatment varies, as long as water quality is not impaired.

C.2 Construction grants that are not channeled through basin authorities should not cover treatment capacity intended for industrial wastes. Instead, industry should pay municipalities or other treatment agencies a service charge for treatment that covers the proportionate share of the cost at any facilities used for treating their wastes, based on their usage of the treatment capacity.

IV. Hardship Cases

D.1 If some aid to hardship cases is considered desirable, a loan program perhaps through existing agencies, would appear to be the best approach.

D.2 In addition to possible loan programs where plants may close rather than pay for waste abatement, extra time for compliance should be considered to help ease transitional difficulties.

D.3 Hardship case aid should be limited to situations where plant closing will cause significant unemployment in an area currently or potentially depressed and where, therefore, workers will have difficulty in becoming re-employed quickly.

D.4 One important program to alleviate the impact of hardship situations would be programs aimed directly at assisting the workers who become unemployed as a result of the plant closure.

V. Scarce Inputs to Pollution Control

E.1 Some material shortages resulting from general economic conditions could cause delays in completion of treatment plants but no specific action seems warranted in this area.

E.2 Sanitary engineering services may become in short supply at current prices as pollution control activity expands. Further graduate training grants and programs designed to train and assist entrants from other engineering specialties could help alleviate these scarcities.

E.3 Many jurisdictions are experiencing a real shortage of qualified sewage treatment plant operators — especially where salary scales are relatively low. Desirable measures to overcome this difficulty include coordination with ex-

isting job retraining programs, creation of further facilities for such training, national exchange of information on job vacancies and a systematic study of the labor market for treatment plant operators.

¹ The Cost of Clean Water, Federal Water Pollution Control Administration, January 1968.

² Ibid.

³ See Kerri, Kenneth D., "An Economic Approach to Water Quality Control," Journal of the Water Pollution Control Federation, Vol. 38, No. 12, December 1966, p. 1883, and Johnson, Edwin L., "A Study in the Economics of Water Quality Management," Water Resources Research, Vol. 3, No. 2, Second Quarter 1967.

**the current
situation**



In order to put the entire discussion of this report in perspective, it is necessary to review the current situation in the area of public policy related to water pollution. This chapter provides such a survey. It considers in turn the following aspects of the present state of water pollution control: 1. types of requirements for water pollution control currently being created, which firms and government agencies will have to meet; 2. the costs of meeting such requirements; 3. current Federal programs designed to assist industry (and state and local governments) to meet those costs; 4. current enforcement procedures and 5. how business is likely to react.

At the moment the complex process of creating stream standards under the Water Quality Act of 1965 is moving forward. These standards are being proposed by state agencies for each mile of interstate streams within their boundaries. They then must be approved by the Secretary of the Interior. As of the beginning of January 1968 the stream standards of some states have been approved and action was still pending in many other cases.

In general, these standards require all plants and government agencies to provide a minimum of "secondary treatment or its equivalent." This means roughly removal of 85% of the suspended solids and of the organic waste material that decays in water.¹ Such removal standards have sometimes been relaxed for waste sources that are use deep ocean outfalls — in such cases, lower removal rates have been approved. It is not yet clear in individual cases how much account will be taken of process changes that lower the amount of waste produced, and whether firms will be able to substitute such internal changes for the amount of treatment of what would otherwise be required at the outfall from their waste pipes.

It does not appear that current standards will make very much allowance for seasonal variations in the assimilative capacity of streams in specifying acceptable treatment levels. Similarly, firms with widely different costs for removing a given amount of waste will apparently have to perform similar levels of treatment if located on the same stream of a river.

The assumption behind the current procedure is that the states will balance the costs and benefits of pollution control in setting appropriate standards. However, the Federal Water Pollution Control Administration's guidelines to the states for setting standards can be, and have been, interpreted by some as implying that no stream standards can be set below current quality levels. The exact status of current policy on this point is unclear. But as pointed out in the introduction, blanket rules that do not allow decision makers the flexibility of balancing costs against benefits have little to recommend them as guides to efficient and responsible public policy.

In any case, this brief review of the sorts of requirements business and governments soon will be confronting leads us to the next question in this survey of the current situation: how much will it cost to meet stream quality standards?

Estimating the costs of sufficient waste abatement to meet stream standards is an extremely difficult problem. Accurate data on pollution loads and abatement costs for industrial waste are extremely scarce. In addition, any projection involves tremendous uncertainty. For instance, will any new discoveries lower the costs of waste abatement? In addition, the types of incentives and other public policies decided upon could significantly affect the actual total costs that eventually result. If it is true, as argued elsewhere in this report, that there are significant cost advantages from large scale treatment plants and regional agencies, then if public policy moves to help create such plants and agencies, the costs of abatement ought to be lower

current regulatory requirements

the costs of waste abatement

than they otherwise would be. In addition, estimates of the impact of factors like obsolescence and the facilities needed to handle growing population and industrial production can only be approximate predictions at best. In light of all these difficulties, it is not surprising that previous estimates of the cost of pollution abatement have been based on very simple economic and technological models or were straightforward guesses based on little or no data. The Federal Water Pollution Control Administration has just completed a large study which provides the most reliable estimates of the costs to society of pollution abatement available to date.² These figures are the source of all the estimates which follow.

municipal costs

Municipal costs (see Table I) were estimated through the use of general models of the economy that forecast the national requirements for adequate municipal facilities by the fiscal year 1973. It was assumed that adequate treatment is equivalent to secondary treatment and that the total urban population will have its wastes treated. No assessment was made for operation and maintenance costs for sewers or for the costs of installing storm sewers where no sewers exist at all. Also no estimate is provided for the cost of solutions to the problem of pollution caused by storm water and snow melt runoff overloading current combined sanitary and storm sewers. Further, the cost estimates are only for those costs eligible for Federal grants under current programs and hence exclude land costs, relocation, and other associated expenses.³

Cost Estimates in 1968 dollars for Treatment of Municipal Wastes for the Five Year Period Ending in 1973

Type of Expenditure		Cost Estimate
Capital Costs	Capital outlay for upgrading existing facilities, reducing current unmet needs and providing for increases in urban population.	\$6.8 billion
	Sanitary sewers for urban dwellers not connected to municipal sewers.	\$6.2 billion
	Replacement of depreciated facilities	\$1.2 billion
Total		\$14.2 billion
Operating Costs	Operating and maintenance for new and existing municipal treatment facilities, five year total	\$1.4 billion

Source: U. S. Department of the Interior, Federal Water Pollution Control Authority, The Cost of Clean Water, January 1968, Table I.

Table I makes it clear that even exclusive of land costs, interceptor sewers, and a solution to the combined sewer problem, pollution abatement to meet secondary treatment standards would cost about \$8 billion over the next five years for capital facilities and use the \$6 billion for sewers. On the other hand, the estimates do not consider the possibility that some municipalities would have lower costs because deep ocean outfalls would allow lower treatment levels.

industrial costs

The industrial estimates are based upon a series of detailed technical studies of the wastes produced by various industries. Waste-to-product ratios were calculated for a few firms in each industry and were then applied to published estimates of national output. The estimates are based on the assumption that treatment facilities are required that will remove 85% of suspended solids and of the biochemical oxygen demand exerted by organic wastes. Besides the many obvious difficulties of this kind of estimating approach, there are three important, partially offsetting difficulties with the estimates. First, technological change, which tends to reduce costs, is not accounted for, thus biasing the estimate upward. Second, substantial treatment economies may be possible in the framework of regional

water quality authorities, and such economies too would tend to make the estimates too high. Third, the cost of industrial waste treatment is probably underestimated because the variety of pollutants that result from industry leads to some unreliability in using biochemical oxygen demand (BOD) and suspended solids as a basis for evaluating waste loads. Despite these problems, the industrial cost estimates are better than any previously available.

Cost Estimates in 1968 dollars for Treatment of Industrial Wastes in the Five Year Period Ending in 1973

Capital Costs	Capital cost to overcome existing deficit in industrial waste treatment, and to keep pace with industrial growth.	\$1.8-\$3.6 billion
	Replacement of depreciated facilities.	\$0.8-\$0.9 billion
Operating Costs	Operating costs for existing and new facilities — five year total.	\$3.0-\$3.6 billion

Source: The Cost of Clean Water, op. cit. Table I.

From this table one can estimate that capital costs will range from \$2.6 to \$4.5 billion. The total for maintenance and operating cost conceals a trend which will rise sharply through 1973. Thus operating costs are estimated to be about \$900 million per year in 1973 dollars up from the projected 1969 level of about \$500 million. One should also note that these estimates exclude the costs of dealing with the problem of industrial thermal pollution, which could cost close to \$1 billion to abate by 1973, as well as not counting the costs of abating pollution from acid mine drainage, animal feedlot runoffs, and salinity produced by irrigation.

Estimates have just been presented which imply that industry will have to spend between \$2.6 and \$4.5 billion by 1973 in order to provide the requisite capital facilities to meet the pollution control standards discussed above, and about the same sum for operating and maintaining costs (see Table II above). It is useful to examine what assistance is currently being offered to business firms to defray some of these expenses. Following the distinction made in the Introduction, it is helpful to note that such current programs seem to have in fact been created primarily as assistance, to reduce the costs to industry, rather than having been specifically and consciously designed as incentives to elicit certain types of desired behavior.

To begin, it should be noted that it is not always possible to estimate exactly how much aid is being given to industry under various programs. Some projects, like research and development programs, can have very significant though indirect impact by creating new technology that will lower the costs to industry of pollution abatement. Unfortunately, such cost savings are difficult to measure and still harder to predict. With this in mind, the following existing government programs will be considered: federal tax incentives, research and development and demonstration grants, small business administration loans, and aid to municipalities.

The most significant form of current aid to industry is the very substantial sharing of pollution abatement costs that is already being undertaken by the Federal Government under the current tax structure. It is important to note that this aid will continue to be provided for all future investment in pollution control facilities. The net impact on industry profits of expenditures on pollution abatement equipment is much less than the dollar amount spent. This is because a firm is allowed a depreciation write-off for investment in pollution abatement facilities that will result in a lower tax liability for the firm than it would have had without the pollution investment. For every dollar of depreciable capital investment undertaken for pollution control purposes, the government currently pays from 30% to 45% of

current assistance to industry

federal tax assistance

the firm's cost in the form of a reduction in corporate tax revenues, although the exact amount of aid depends upon the tax accounting methods and discount rate of the firm involved.⁴ Of the approximately \$2.2 billion industries have invested for capital facilities for waste treatment, between \$660 and \$990 million of this investment has been financed by the Federal Government.⁵

Similarly, the operating costs for treatment plants can be written off annually against current expenses for corporate tax purposes. The government today is providing over \$200 million a year for water pollution control in the form of reduced tax revenues, or half the approximately \$400 million that industry spends annually for pollution abatement operating and maintenance costs.⁶

In this connection, it should be noted that, while the current tax laws provide substantial aid to industry, they do so for other types of industrial investment and current expenses as well. Thus, while there is an incentive to industry for pollution control spending in the current system compared to a situation where such expenditures were not tax deductible, the current tax laws do not favor investment in pollution control facilities over other types of investment.

research grants and demonstration grants

Both the research grant program and the demonstration grant program benefit industry in two ways. Some of the funds distributed go directly to industry, underwriting research on industrial pollution control problems. Other funds go to universities or to state or local agencies. But these latter programs also produce knowledge that can be helpful to industrialists seeking to abate their pollution at lower costs.

Between Fiscal year 1967, and the current fiscal year between \$5 and \$10 million has been spent for research and demonstration projects on the problems of industrial pollution control. These totals conceal a steadily rising trend of expenditures which may be expected to continue at substantial levels in the near future.⁷

small business administration loans

Another source of aid to industry for water pollution abatement is loans from the Small Business Administration. As of early 1967, this agency had made 21 loans for pollution abatement investment totaling \$1.3 million, at an interest rate of 5½% per year.⁸

The Small Business Administration (SBA) program benefits industry in three ways. First, industry can save half the difference between the 5½% interest rate it pays on these loans and the higher rates it would have had to pay to obtain funds from private sources. (Only half the interest difference is saved because all interest payments are deductible for corporate income tax purposes.) Second, some small firms might have difficulty in obtaining any loan capital on the open market for pollution control investment because, especially when credit is tight, banks often "ration" available funds in favor of large borrowers. Third, such loans are frequently for longer time periods than credit available in private capital markets.

other government loans

There have also been grants for pollution control purposes under the Public Works and Economic Development Act of 1966, as well as under some previous legislation. Under this legislation, loans can be made directly to industry, some of which could be used for investment in abatement facilities. Also, loans can be made for water lines and sewage systems for industrial parks. In addition the Economic Development Administration, which currently administers these loan programs, also provides technical assistance to industry in dealing with its pollution problems.

aid through municipalities

An important source of indirect aid to industry is that given to municipalities. This aid is primarily in the form of grants for up to 50% of the cost of constructing waste treatment facilities. As is discussed later in the report, economies of scale obtain in both the construction and the operation of pollution abatement facilities. Thus, in many cases, it may be cheaper for society, in terms of the total expenditure of scarce resources, for firms to treat wastes jointly with municipalities in a few large abatement plants, rather than individually in many small ones. Aid to industry via municipalities is of great practical importance because at least a quarter of indus-

trial waste treatment today is performed in municipal plants.⁹ For fiscal year 1968, \$203 million was appropriated for such aid.

In addition to the more or less direct programs just discussed, there are a wide variety of government activities that substantially assist business firms trying to comply with pollution control regulations. A great number of agencies generate information useful to industrial firms or to other government agencies dealing with pollution problems. Just a few might be mentioned to illustrate this point. There are, for example, geological Survey data on river flows and rainfall, information from the Bureau of Mines on the problems of Acid Mine Drainage, research results from the Department of Agriculture on salinity problems from irrigation and methods of abating pollution from feedlots, work done by the Atomic Energy Commission to help reduce the thermal pollution problems of atomic reactors used for electric power and data from the Bureau of Commercial Fisheries on the impact of various pollution problems on fish life.

other aid to industry

Before discussing further incentives to industry to comply with water quality standards, one must be aware of the "negative incentives" in the form of enforcement action which already exist. These procedures provide the "stick" behind any "carrot" which new legislation might create.

current enforcement procedures

At the moment there are two possible enforcement procedures open to the Secretary of the Interior. First, where waste discharges violate approved state stream standards, the case can be taken directly to the courts for equity proceedings. However, stream standards are only now being created. Existing legislation still includes as an alternative the older enforcement procedure which is based on a complaint that pollution discharges injures health and welfare. Under this method, conferences and hearings are held to work out a mutually satisfactory abatement program. If such cooperative measure fail, the Secretary of the Interior still has the right to have recourse to court action to obtain adequate abatement. All enforcement action to date has utilized these latter procedures but as stream standards are approved it is probable that the more direct court action possible under such standards will come to be utilized more heavily. In any case, once the Secretary decides on court action, he refers the complaint to the Attorney General. Because court actions under the enforcement mechanism are civil equity cases, not criminal ones, the resulting decisions are enforced by contempt of court proceedings.

Thus, any firm that violates the stream standards must face the ultimate possibility of court action with its attendant expense, inconvenience, and poor public relations. However, such court proceedings may well prove time consuming, especially since the existing legislation gives the courts a very broad responsibility in reaching decisions on enforcement cases, and declares a large number of factors to be relevant to the judgment. Thus the "negative incentive" provided by the enforcement system, though significant, is not overwhelming.

To put the discussion in the rest of the report into perspective, it is useful to review the current situation confronting an industrial firm which produces substantial water pollution. This analysis will provide a basis from which to compare the probable impact of alternative incentive schemes as the discussion proceeds.

firm behavior in the current situation

As this report is being written, the Secretary of the Interior is still in the process of reviewing many of the state water quality standards. As these standards are approved, firms have the option of complying with the regulations within an adequate

period of time or facing enforcement procedures. In fact, however, the alternatives open to these firms are more complex. Industry may decide to cooperate wholeheartedly with the pollution abatement effort, or it may seek to follow one or more strategies to delay meeting the regulations.

An examination of the current situation makes it easy to understand why at the moment incentives to delay are very substantial. First, there is no significant sum of money available to industry to help finance pollution control. This is partly because the Vietnam war has put so much pressure on the Federal budget. In view of this, a firm might well feel that delaying now would enable it to take advantage of any incentive programs developed in the future, when more government funds become available. On the other hand, if the situation in Southeast Asia does not diminish in importance within a reasonable time period, a firm might well conjecture that pollution abatement will not continue to be a vital national issue, and that it will be possible to resist enforcement pressure under such circumstances.

The most direct advantages to the firm which delays are savings in operating costs for however long it delays, and the savings of having been able to use profitably in the interim the capital that would have been employed in constructing waste treatment facilities. Another important potential advantage of being able to postpone any construction is the possibility that new technology will be developed that will make abatement efforts less expensive to undertake. These benefits are independent of the action of other firms; in addition a firm might believe that the last firms to clean up along any river will face less enforcement pressure because the water has become cleaner. This might be wise strategy in that if abatement efforts produce less satisfactory results than anticipated, the remaining firms might face especially high standards.

For a firm that wants to delay, there are innumerable ways to postpone the actual construction of control facilities. Engineering studies have to be made to derive the least cost method of abatement. Design studies must be undertaken and perhaps revised in the light of new technology. Many of the concerns that do such work will be very busy because of the high demand generated by the national program, so that even the most genuinely cooperative firms might have difficulties in meeting pollution control deadlines. If a firm exceeds the deadline, enforcement personnel may be in short supply, thereby hampering enforcement efforts. Finally, a firm might take the battle to court.

There is an added complication with firms tied into small municipal sewage systems, such as resource-based industries in comparatively rural locations. An industrial plant in a small town could claim to be a part of the municipal sewage system, and assert its willingness to pay a fair share of the municipalities' costs for treating its waste. However, under the current program, federal construction grants to municipalities have been running much lower than initial authorizations, and at a much lower percentage rate of subsidy than designated in the original legislation. In some state the actual Federal share has been as low as 3% as opposed to the 50% envisaged originally. A small municipality with a debt limit enforced by the state constitution and hence unable to finance a large plant to treat waste from its industry could be a very difficult enforcement problem. The town could point out, with complete honesty, that the Federal government was not contributing anywhere near the share of the capital costs it had promised. As part of the municipal system, the offending firm could not be directly reached by enforcement proceedings.

summary

1. Water quality standards are being created which seem likely to impose between \$3.2 billion and \$4.3 billion in capital costs by 1973 on industrial firms if they are to comply, and operating costs rising to over \$900 million a year by that date.
2. A variety of current programs provide assistance to industry, most notably existing corporate tax regulations and a variety of research and development, and training and demonstration projects sponsored by the Federal Water Pollution Control

Administration. Also important are Federal construction grants to municipalities which currently treat about 25% of all industrial waste.

3. Despite these assistance programs, industrial firms that are significant pollution sources have a real incentive to delay in complying with standards because of the cost savings they might be able to achieve by such tactics. Moreover, the "negative incentives" of enforcement proceedings are less than compelling.

This then is the context within which any incentive program for industrial pollution abatement must be considered, and in terms of which its impact should be judged.

¹ This waste is measured by the Biochemical-Oxygen Demand it produces, usually abbreviated BOD or BOD₅ — where the subscript "5" indicates that measurement is based on a chemical analysis that allows five days for the waste to decay as a reference point for the measurement.

² The Cost of Clean Water, Federal Water Pollution Control Administration, January 1968.

³ Ibid.

⁴ The more rapidly the investment is depreciated for tax purposes, the sooner the tax savings accrue to the firm, and hence the more valuable they are. The higher a firm's discount rate, the less value money has if it accrues later as opposed to earlier. The range of value in the text reflects the value to the firm of tax surveys if it uses discount rates of from 4% to 10%, approximately twenty year depreciation lives for the assets, and either straight line or "sum of the year's digits" depreciation methods.

⁵ The Cost of Clean Water, op. cit.

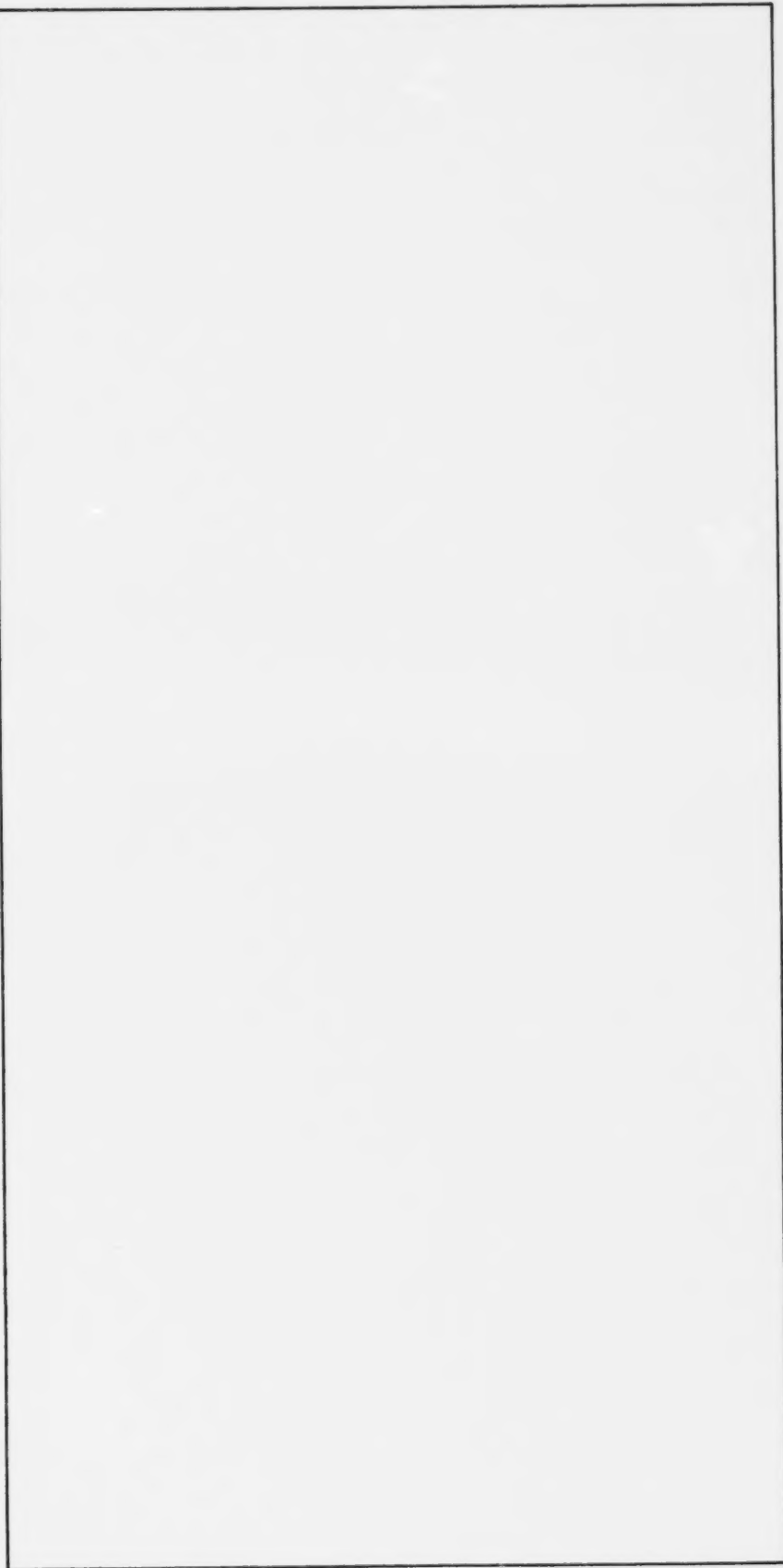
⁶ Ibid.

⁷ Information supplied by the F.W.P.C.A.

⁸ Small Business Administration private communication.

⁹ The Cost of Clean Water, op. cit.

**criteria for
program
choice**



In order for the designer of an incentive plan to evaluate and compare alternative programs, it is important that he have a general framework within which to analyze these proposals. The following three sections examine a set of criteria and discuss the basic considerations for deciding public policy. In the discussion examples are used which illustrate the basic problems of policy choice in water pollution control. Please note that the examples were chosen purely for illustrative purposes and no policy recommendations should be inferred from them. Rather, the specific recommendations of this report are contained in the substantive sections which follow this one.

An efficient water pollution control policy is one that achieves water quality standards at minimum social cost, i.e., at the lowest cost in terms of real resources used. This section discusses what constitutes such an efficient pollution control program for an individual firm, then examines efficient implementation of a water pollution control program for a river basin, and finally looks at the problems of scheduling such a program efficiently over time.

efficiency

The concept of marginality enables a decision-maker to decide what is the least cost method of achieving a given goal. Suppose the objective of a firm is to meet water quality standards at minimum costs. To achieve this objective, the firm should spend each dollar for quality control where it will buy the most water pollution abatement. More specifically, the firm should spend each additional dollar in that area which nets it the greatest increment in stream quality. When the firm is operating in the least cost manner, the contribution of the last (i.e. "marginal") dollar spent on each alternative method of pollution abatement will be the same.

efficiency for the individual firm

To see why this is so, consider a firm that has several methods of waste abatement available to it. 1. It can spend money on more careful plant operation and better housekeeping. 2. It can invest in some treatment devices to place at the end of its waste pipe. Or 3. it can invest in new production equipment that will lower the amount of waste it produces in the first place. What happens if the marginal dollar spent on each alternative does not produce the same amount of waste abatement? For example, suppose that in spending somewhat less for more careful operation the firm would increase its waste by a given amount. Then suppose that by spending that same saving for a better treatment device it could have removed more waste than the increase in waste that resulted from spending less on operation. If this were so, clearly the firm could have achieved the same waste removal at less cost by making the switch. Thus because the marginal amount of waste removal for additional money spent on each alternative was not equal, the firm was not removing its waste in the least cost manner.

In general, because it is concerned with profits, the firm can be expected to choose among alternative pollution abatement methods so as to minimize the costs to itself of meeting abatement requirements. Because some treatment processes and facilities can be purchased only in large units, simple marginal analysis can only be used in an approximate manner to indicate efficient choices. However, if the costs to the firm of using various alternative approaches were the same as the costs to society, the efforts of the firm to minimize its own costs should also lead to a socially efficient solution.

When will the least cost solution for the firm and for society not coincide? There are two major possibilities. First, the existing relative market prices for the goods and services that the firm uses for pollution control might not reflect the real relative social costs of their own production. It is very difficult to say to what extent this is actually so for inputs used in pollution control. But since these inputs are the same as those used by many basic industrial processes and for many other types of capital facilities, refusing to accept the assumption of the approximate efficiency of market allocation in this case is the same as refusing to assume it for much of the American economy in general. Therefore, the arguments in this report largely do assume that relative market prices reflect real costs.¹

A second situation in which the efforts of a firm to minimize its private costs would not lead to minimum social costs is where an incentive scheme has resulted in net relative prices to the firm that are different from market prices. Note that it has been assumed that the latter reflect real opportunity costs. In this case, the firm will choose a method for waste control that represents the least cost for itself, though not the least cost for society.² Obviously it is important to try to avoid incentive programs which produce this kind of result. For example, if the firm is offered a grant for pollution abatement in the form of a "lump sum transfer" independent of the type of technology the firm uses to curtail its wastes, then the relative prices of different abatement methods will remain unchanged and the firm will choose the same combination of abatement techniques it would have prior to the grant. If, by contrast, the firm is offered a tax concession that allows it to write off its purchases of abatement equipment but does not allow it to write off additional expenditure for land or plant operation, then the relative after-tax prices facing the firm will be different from the relative pre-tax prices. In this case, since the private cost of resources to the firm after the tax concession is no longer the same as the social cost, the firm's attempt to minimize private costs will cause it to choose a treatment method that will not minimize social costs.

efficiency for a river basin

In order for society to attain a given level of stream quality at the least real cost, it is essential not only that each individual plant treat wastes efficiently but that the total amount of abatement performed be allocated among firms in an efficient way. Thus, it is necessary to consider the problem of abatement on an aggregate level of decision making, that is, with respect to a river basin as a whole. Suppose the incentive scheme offered to industry were neutral with respect to the relative prices of resources. However, if industry at the same time is required to implement rigid abatement standards that say every firm is required to treat a fixed percentage of its wastes, then even if every firm succeeded in meeting this standard at minimum private cost, the real resource cost to society might be unnecessarily large.

For example, if two firms are located on opposite sides of a stream and one has access to cheap, flat land for an oxidation pond while the second plant does not, it would be inefficient for these firms to be required to treat wastes identically. Perhaps the stream quality can be maintained at least cost by having the first firm do the bulk of the treatment and relying on the assimilative capacity of the stream to accommodate the wastes of the second firm. If so, this approach should be adopted as the most efficient solution for maintaining water quality in the river basin.

Once a level of stream quality is chosen, it would be most efficient, from society's point of view, for firms to be required to treat wastes on the basis of their relative per unit costs of waste removed until the stream standard is satisfied. That is, as long as Firm A's costs for additional units of pollution abatement are above Firm B's, Firm A should not be required to treat its wastes. Only when Firm A's costs for further treatment rise to Firm B's costs should the additional cleanup be shared between them if stream standards have still not been satisfied. Such a practice will save the economy the scarce resources that otherwise will have to be spent to obtain sufficient treatment to maintain stream quality.

In the most general case, efficient pollution abatement in a river basin means balancing the marginal costs of a wide variety of alternatives against each other in order to arrive at the least cost solution. Not only must one examine various patterns of treatment at individual plants, but such possibilities as constructing large facilities to treat the wastes of several plants or towns, or pumping the sewage elsewhere should also be considered. Similarly the use of techniques like low-flow augmentation, in-stream aeration, the seasonal scheduling of waste discharges, or the seasonal operation of treatment facilities must all be evaluated. All this must be done in a highly uncertain world where future prices and opportunities are not known, where markets are imperfect and where rivers do not behave in an exactly predictable manner. Merely stating the problem makes it clear that efficiency is a goal that can at best only be approximated in actual decisions. The question is which kinds of decisions are most important, and which choices will make the most difference. Thus one of the most basic implications of the efficiency argument is the importance of trying to understand which "margins" are most crucial for rational decision-making about pollution control.

It is important to recognize that the final total of costs and benefits resulting from the nation's water pollution control program will depend upon the timing of the expenditures undertaken for pollution abatement. There are both costs and benefits associated with speeding up or slowing down the rate of the country's investment in water quality. Obviously it is not necessarily desirable under all conceivable circumstances for the nation to attempt to attain its pollution abatement objectives as quickly as possible. The basic fact to consider is that the availability of government funds changes over time.

For a given government budget where any one program is expanded, others must be contracted, or expanded less than they otherwise would be. Consequently, any project has what are known as "opportunity costs," namely the value of the benefits that would have accrued to society from the programs that had to be foregone in order to make room in the budget for the program actually undertaken.

At the moment such "opportunity costs" are very high. Partially as a result of the Vietnam conflict, government funds are particularly scarce and must be allocated among many important domestic programs such as housing, education, and poverty as well as meeting the needs of defense, space and foreign aid. Since some shaving of funds is a result of recent developments, it is necessary to consider whether it is wise to plan on attaining water quality goals more slowly than was envisaged when the current program was first begun. The Congress may actually share this viewpoint since the actual appropriations for water pollution control have been significantly lower than the amounts authorized in the initial legislation.

However, there are costs associated with postponing pollution control expenditure. As long as streams remain polluted, society cannot realize the benefits obtained from clean water. The fact that Congress has enacted major legislation requiring significant sums of money to combat pollution indicates that society values these benefits and they should be postponed only when it appears that the loss from doing so is smaller than the cost savings effected at the same time.

In some special cases, the costs of postponing pollution abatement efforts are greater than simply the loss of recreation and other benefits society would have enjoyed in the interim. In the case of some lakes and estuaries, the costs of postponing pollution abatement also include the extra costs that will have to be incurred in order to remedy the cumulative damage that will be done to water quality by allowing pollution to continue. Dumping additional wastes in these cases affects the natural balance in the water in such a way that the damage to water quality is cumulative and will continue even after additional pollution is ended, unless corrective action is taken. The amount and cost of the corrective action eventually needed will depend upon how long pollution continues. In some of these cases the damage done to water quality can never be reversed; in others, it can only be overcome at significantly higher costs than those that would have been incurred with a more rapidly developing program. For example, in some situations dumping wastes in an estuary results in additions to bottom deposits. These deposits will eventually have to be dredged up if water quality is to be improved. In such cases, delay would increase the costs of attaining water quality standards significantly.

Thus, if it is necessary to delay the pollution control program in general, certain special lake and estuary programs should be affected as little as possible. The costs of retarding pollution abatement on Lake Erie are much higher than the costs of delay in cleaning up a flowing river.

Another important aspect of the timing of pollution abatement efforts is the possibility that the development of new treatment technology will lower costs considerably. Much of the current treatment technology is old and an intensive research effort is currently being undertaken by industry, government, and the universities. Thus, any general program for pollution control that emphasizes undertaking a great deal of investment in a short period of time runs the risk that plants will be constructed which could have been built at lower costs had more time been taken to await the development of new methods. However, the development of any technical improvements is always an uncertain matter, and it is at best only a possibility that such a situation would occur.

Once a decision is made on what timing pattern is desirable, appropriate incentives can be constructed to help bring about the chosen timing pattern. Assistance programs that terminate after a certain date encourage people to act more quickly. The promise of more generous funds in the future encourages them to delay. If one is willing to use existing agencies as the basis for a program, it will probably be accomplished more quickly than if the decision-maker decides that new administrative entities have to be created. All these are aspects of any program which are appropriate elements to consider in making policy decisions.

equity

Equity is a concept of "fairness" and is used to convey the value judgment that equal entities should be treated identically and unequal entities should be treated impartially. What is "fair" or "equal" or "impartial" can ultimately be defined only in terms of individual values; however, since the policy maker must be concerned with what is "fair", the following section will examine some of the problems of interpersonal and inter-firm equity which will arise in the implementation of a pollution abatement program.

interpersonal equity considerations

The important point about what is "fair" is that it has to be designated by the policy maker. It cannot be determined by empirical observation. If two individuals are to be treated equitably, the policy maker must specify what this impartial treatment entails. For example, consider two consumers, A and B. Consumer A buys a product which involves water pollution in its manufacture and Consumer B does not. Assuming that Consumers A and B are to be treated equitably, Consumer A should not get preferential treatment because his tastes differ from B's. However, unless Consumer A is required to pay all the costs of producing the product he buys, including the social costs of the water pollution resulting from its manufacture, then the non-purchaser of the product, Consumer B, is less well off than A because society is subsidizing A's purchase but not B's.

More specifically, if Consumer A buys paper and Consumer B buys fish and if they are to be treated equitably, Consumer A must be required to pay a price for paper which includes the extra cost of fishing in waters polluted by paper production. If instead, Consumer B has to pay a higher price for fish, he is subsidizing A's purchase simply because their tastes differ and this is inequitable.

The implications of this example for an incentive program for water pollution are straightforward. An across-the-board tax incentive program to industry will not make the relationship between Consumers A and B any more equitable, unless a larger proportion of the high taxpayers purchase the pollution-intensive product. Alternatively, if industry is assessed for the quantity of pollutants discharged and it passes these higher costs on to the consumer, then the relationship between Consumers A and B will be more equitable because Consumer A will be paying the full price for what he buys.

A closely related equity problem is that of who should pay for water pollution, the industrial or the non-industrial users of the water. The answer to this question is not obvious and again depends on the assumptions of the policy maker. Consider the following 3 hypotheses:

1. If the industrial user has the right to the river, then he cannot fairly be charged for polluting the water and in fact, should be paid if he is forced not to pollute it. Thus, a private fisherman must either sustain the extra costs and inconvenience of catching fish in polluted water or pay the paper mill to move or cleanup.
2. If the non-industrial user has the right to the river, then industry must be responsible for all the costs pollution imposes on society. Whether or not the paper mill locates on the river before or after the private fisherman comes to fish there, it has no right to damage the water. In this case, the paper mill will have to compensate the fisherman for the additional costs of fishing or else assume the costs of cleaning up itself.

3. If industrial and non-industrial users share the right to the river, then they must share the costs of pollution. The current pollution abatement program appears to be based on a similar assumption. At the moment, industry is responsible for providing pollution abatement facilities but taxpayers sustain some of the costs in the form of the tax write-offs available to industry for the construction of abatement equipment. However, this situation represents a compromise between industrial and non-industrial users only if non-industrial users and taxpayers are essentially the same group.

Questions of inter-firm equity usually involve the problem of treating unequals impartially. Firms which are not equal with respect to investment in abatement equipment, profitability and size will be discussed.

interfirm equity considerations

To begin, consider the problem of incentives to industry for pollution control from the point of view of the firm which has already installed some abatement equipment and is currently treating its wastes, at least to some extent. Suppose, in an effort to encourage other firms to meet abatement standards, the government allows industry a tax concession on new investment, such as accelerated depreciation or investment credit. Then, the firm which has already made an investment in abatement facilities will be at a disadvantage relative to the firm which has not. That is, the investment will cost less now than it did in the past and this is inequitable.

Almost any scheme to encourage firms to comply with the present pollution abatement standards will put the firm that already has some abatement facilities at a disadvantage relative to the firm that does not. The point is that policy makers should treat firms as impartially as possible under the circumstances. One possibility for example is for regional water quality authorities to be established and to assess firms for waste treatment costs in proportion to the concentration as well as the quantity of effluents discharged. The firms which have already installed abatement equipment would be able to use it to minimize treatment charges imposed by the regional authority. In other words, firms which already had abatement equipment will not be "punished" for having bought it prior to the government's incentive scheme.

The problem of profitability has similar implications for the appropriate incentives to industry to comply with pollution abatement standards. It might well be public policy to favor the profit-making firms because they are on the whole efficient. However, it is important to realize that current profits are not the only indication of long run efficiency. A firm which has just begun operations or one which is suffering a temporary setback due to abnormal market conditions, may show zero or even negative profits for a time and yet be viable and efficient in the long run. The point is that it may be inefficient as well as inequitable to assist only currently profitable firms to achieve water pollution control standards as painlessly as possible.

A tax incentive scheme would benefit only the profit making firm and then only to the extent that the firm's total tax liability is reduced by the additional amount of depreciation it is allowed to charge against its profits. Alternatively, a lump sum grant to firms regardless of profit position or to municipalities would be neutral and thus equitable with respect to firm profits.

Different incentive programs will also affect the relative competitive positions of large and small in two important respects. First, because of economies of scale in treating wastes, the per unit cost of waste treatment decreases as plant size increases. This puts the small firm, which only requires a small abatement plant to treat a small amount of wastes, at an automatic disadvantage relative to the large firm. Any incentive scheme that encourages firms to build their own treatment facilities would raise the costs of production of small firms relative to those of larger firms because their per unit costs of treating wastes would be higher. If a regional authority were responsible for the construction and operation of the abatement facilities and were to impose a per unit service charge for waste treatment on all firms, then both small and large firms could benefit from the economies of scale and the small firm would not have to incur higher treatment costs than the large firm.

Second, some programs for pollution abatement would affect the large and the small firm differentially with respect to their relative access to the capital market.

An incentive scheme, such as a tax concession that only partially covered the costs of abatement, might mean that firms would have to borrow funds in the capital market to cover the remainder of the cost. In general, however, large firms have easier access to capital markets and pay lower interest rates. Thus, small firms would pay more for their capital (if it is available at all through the market), essentially to perform the same abatement functions as large firms. Again, a regional water quality authority treating wastes for a service charge, would be more equitable in this regard.

feasibility

Incentives to industry for pollution abatement will be useful only if they are practical. There is little value in designing a theoretically elegant incentive scheme if it cannot be implemented in the real world.

administrative feasibility

The general area of administrative feasibility includes the following problems: the administrative costs of the incentive program; the possibility of effectively enforcing an incentive program; the ease and efficiency with which an abatement program and an incentive scheme can be modified over time in order to meet changing conditions.

The administrative costs of implementing any program must be balanced against the other benefits in reaching a policy choice. For example, clearly defined rules for applying any incentive scheme might be easier and less costly to operate than a more complex set of criteria, but the rules might also be less efficient or equitable in their impact. Some program alternatives may be less costly because they make use of an existing organizational structure, like the Internal Revenue Service, while a newly created system, such as a river basin authority, may cost more until it is fully developed and operational. However, an existing agency might not be fully attuned to the imperatives and perspectives necessary for the successful operation of the new program.

Feasibility is not just a matter of costs however. In some sense balancing administrative costs against the benefits of a larger organization is essentially another problem in efficient planning similar to the problem of evaluating the costs and benefits of any pattern of spending on alternative methods for attaining better water quality. Feasibility on the other hand also implies the more basic question of whether the required resources will be available at all at the time they are going to be needed by a proposed program — regardless of the price. If there simply will not be enough engineers to design all the new treatment capacity required by a rapidly accelerating program, then such an approach is infeasible, or even impossible in terms of actual options open to policy makers.

Once an abatement program is established, there are administrative problems in enforcing and carrying out its provisions. One aspect of this problem is the possibility that current technology cannot provide the kinds of information a particular enforcement strategy would require at reasonable costs. Additional difficulties might arise from a shortage of trained personnel. Such limitations restrict both the types of programs which can be achieved and the pace at which an otherwise feasible policy can be implemented.

Another important aspect on which to judge alternative programs, especially for enforcement, is the difficulty of administering plans where bribes and other forms of corruption are an attractive temptation for the violator, and it is difficult or impossible to police a number of decentralized inspectors and field crews. For example, service charges for industrial treatment based on metered water use, or fixed formulas, are more immune to such difficulties than those based on field sampling of effluent characteristics. However, administrative considerations are only one factor among many which have to be weighed in making final choices.

Finally, it is desirable that any administrative authority arrangement obtain the necessary data in order to both allow for an evaluation of the program and to provide

a basis for modifying the program over time. Any program will confront changing conditions in the form of the availability of funds, abatement technology, social evaluation of water quality, and so on. Ideally, information on all these factors would be regularly collected and incorporated into the operation of the program, leading to the continued adjustment and improvement of the pollution control effort.

The political situation and the nature of the political process must also be appreciated when trying to formulate any pollution control program; it is not sufficient for a program to be merely technically possible or economically efficient. A judicious decision-maker must also consider the limitations placed on his actions by political reality.

political feasibility

The term "political feasibility" refers to the nature of the political process as well as to actual positions. In designing any incentive scheme, the policy maker must decide between the flexibility offered by general guidelines and the precision of detailed procedures. If legislation is too specific, it risks obsolescence. On the other hand, more flexible legislation makes possible arbitrary administrative actions. For example, suppose detailed water quality standards were written into legislation directly. When changes developed in technology, pollution loads, or tastes, needed changes in standards could not be made without laborious legislative action. Conversely, broad general rules can rely too heavily on the discretion of the individuals who are actually running the program.

Another dimension of potential political difficulty that must be considered, is the relationship of specific incentive programs to more controversial policy issues. Questions like local control, erosion of the tax base, and fairness to municipalities and to industry have affected the formulation of the nation's current water quality legislation and will inevitably be involved in any decision on industrial incentives for pollution control.

Certain types of political problems may well be more severe on the state or local level than they are nationally. Some firms tend to dominate their local communities. Such firms might be able to affect the actual operations of any pollution control program. Suppose, for example, that a policy maker were to decide that efficiency required a firm to pay the full real costs of treating its wastes. If the firm then persuaded the municipality to provide treatment at less than real costs, the policy maker's original ideas would have been seriously distorted by political reality.

Finally, it should be noted that the distinction between administrative and political feasibility is not precise. In some cases, political and administrative considerations interact in shaping basic policy choices. One such choice is that of selecting the appropriate level of government for managing a pollution abatement program. There are some points to be made on all sides of this question. Decentralized control permits greater flexibility in response to changing local opinions and conditions. National authorities, on the other hand, may have more of the technical skill needed to administer complex programs. Also, they are less likely to condone laxity in compliance with pollution abatement standards in order to influence industrial location choices.

¹ Also ignored in this argument are some very complex economic theory questions about the implications of the presence of a few distortions in relative prices for general efficiency. For a discussion of these issues see: Lipsey, R. G. and Lancaster, K., "The General Theory of the Second Best," *Review of Economic Studies*, Volume XXIV, No. 65, 1963-64, p. 11 ff.; Mishan, E. J., "Second Thoughts on Second Best," *Oxford Economic Papers*, New Series, Volume 11, No. 1, February 1959, p. 96 ff.; Baumol, W. J., "External Economies and Second Order Optimality Conditions," *American Economic Review*, Vol. LIV, No. 4, Part 1, June 1964, pp. 359-372.

² This agreement does assume that spending on each alternative treatment method can be varied in sufficiently small "jumps" so that the price changes will change the least-cost private solution. If only a very few levels of investment in each alternative were available, relative price changes might not result in changes in firm choices.

fiscal incentives to industry



In this section of the report we will examine the basic schemes proposed to provide incentives for industry to attain water quality standards. Three direct types of incentives are considered in turn: 1. tax incentives, 2. direct grant programs, and 3. government loan programs. One indirect method of providing industrial incentive is also considered: 4. the current municipal construction grant program. This program assists municipalities and other government agencies in creating facilities that can be used to treat industrial waste.

General criteria analysed in a previous section of the report will be used in this discussion as a basis for many of the conclusions reached. One point should be re-emphasized at the outset. The purpose of an incentive program is to alter the behavior of industrial polluters. Any such program must therefore be judged primarily on its ability to elicit the sort of response from industrialists that the nation's policy makers desire. Failure in this respect means over-all failure for the program. Besides being feasible and equitable, the program must produce more efficient economic results in a more desirable timing pattern.

In discussing various types of tax incentives to industry, a wide variety of specific measures could be considered. Since World War II over 80 bills have been introduced into Congress to stimulate private pollution control investment by means of tax incentives, usually through accelerated depreciation or some form of investment credit.¹ Rather than discuss the many possible options in detail, we will consider first the general features that are shared by almost all tax incentive schemes. Then we can deal with some of the specific features of alternative plans that would most influence the policy maker.

The present value to the firm of the tax savings for pollution control spending under the current tax law is 30% to 45% of the cost of the capital investment and 50% of any operating costs.² The very substantial size of this aid should be kept in mind when considering the argument often made for additional tax assistance, namely, that the community as a whole ought to assume part of the costs for abating pollution. Whether it should or not, the community is already in fact assuming much of the burden of industrial pollution control.

At the moment, a firm faced with enforcement penalties has to balance the net cost of compliance against the rewards for the various delaying strategies discussed previously. Suppose a firm is faced with a \$1 million investment in treatment capacity which will cost \$100 thousand per year to operate. The actual net cost of such a program, after taxes, is about \$550 to \$700 thousand for the capital facility and \$50 thousand a year for operating and maintenance. Now suppose the firm were given the very substantial additional incentive of being allowed to write off 30% of its expenditure in the first year as a tax credit. Counting the additional benefit of the credit, after taxes the firm is now faced with a net capital expenditure of about \$400 — \$550 thousand plus the same \$50 thousand a year in operating costs. This analysis strongly suggests that even with a significant tax incentive, pollution control will remain a large net loss item on the firm's accounts. In light of this fact, it is difficult to see how a tax incentive could persuade any firm that favored a delaying strategy not to delay. Similarly, it is difficult to believe that any firm unable to raise the capital without such a tax incentive would be able to raise it if there were such an incentive. Thus the first important objection which can be made against all of the tax incentive schemes that have been proposed is that they do not provide real incentives to change behavior.

Against the analysis offered here it might be argued that businessmen do not look only at money, and that in fact there are a good number of business policy-makers already poised on the margin of choice — almost but not quite ready to cooperate with the pollution control program despite the cost. It is true that favoring cooperation are considerations like the poor public relations and the annoyance and costs of facing enforcement action that could result from non-compliance. This latter view

tax incentives

tax incentives and industry response

asserts in effect that there are a significant number of cases where such aspects of the situation are almost enough to outweigh the more immediate monetary considerations on the side of delay. If this were the correct view of firm behavior, then even a relatively small incentive might be sufficient to tip the balance in favor of cooperation in a large number of cases. However, the picture presented in this alternative viewpoint does not seem convincing under critical evaluation. Of course many managers do not look merely at short-run money gains. But the point remains that for most firms, pollution control promises to be a large net loss. Some of these firms are relatively small; many produce intermediate goods not sold directly to the public, and hence may be less sensitive to public relations considerations. Further, it seems difficult to believe that there are a substantial number of concerns where the indirect non-monetary costs would so nearly balance the more direct money benefits from delay that a small federal cash transfer would be the margin of choice. That would be coincidence on too large a scale to be credible.

A 30% investment credit, the incentive used in the above example, is a larger tax break than those usually proposed. It amounts to a net benefit to the firm of 15% of the initial cost of the facility. Most of the recent bills introduced in Congress imply net additional benefits to the firm of 5% to 10% of the total capital cost.³ Clearly, the argument against tax incentives is even stronger for incentives of smaller size, like those that have actually been proposed. The essential point is that tax incentives simply serve to make a very unprofitable course of action somewhat less unprofitable. This kind of change in the situation does not seem likely to produce much change in the actions of industrial decision makers. Where industrialists already feel compelled to act because of a concern over public relations, or out of a sense of public responsibility, an incentive that substantially reduces the costs to a firm might lead them to change their behavior somewhat. However the cost savings of all the proposed plans are too small to potentially have much effect in this respect.

Despite agreement among many economists that tax incentive has been successful in inducing investments in general in the American economy in recent years, it should not be expected to work in the case of pollution control, because pollution control is not basically profitable. In the case of a regular investment intended to make money, tax incentives can serve to make an initially attractive possibility still more attractive, or to make a marginally profitable opportunity worthwhile. For pollution control investment however the firm sees an unprofitable program whether or not there is special tax assistance. Contrast this with a profitable investment where raising the return from 6% to 8% might well induce a businessman to invest, especially if he can borrow at 6½%.

tax incentives and efficiency

The second question which must be considered in evaluating all tax incentive schemes is their impact on the efficiency with which pollution abatement is accomplished. Suppose that after taxes, the net relative prices a firm faces in making pollution investment are not the same as the real costs of the resources to society. The firm will use too much of some resources it finds relatively cheap and not enough of other resources it finds relatively expensive. As a result, the real cost of abating pollution will be higher than it has to be, even though the firm itself chooses the method that appears least costly.

Tax incentives of the sort usually discussed are a perfect example of the kinds of policy that can cause this difficulty. Suppose a firm has a choice between two methods of abating its pollution. One method involves purchasing significant amounts of land on which to construct treatment ponds. The other method is to buy a set of mechanical devices. Under current tax law, the investment in mechanical devices would be depreciable, while the investment in land would not be, though the expense of building the ponds themselves by throwing up earthen dikes, etc. probably could be written off.⁴ The point is that, considering tax breaks, the mechanical approach might cost the firm less than the land-using approach, while before taxes, the land purchase method is cheaper. If the prices of the resources involved (land, machinery, labor, etc.) reflected the real value of the resources to the society, then the firm would have chosen a method that actually cost the society more in terms of real resources, even though it cost the firm less after taxes. Thus, one of the crucial questions in evaluating any tax incentive scheme is whether or not it seems likely to produce the kind of inefficiency just described.

There are such a large number of "tradeoffs" in sewage treatment technology, that it is not useful to discuss the impact of tax incentives on all possible margins of choice. Instead we will consider specifically the major area of concern: the effect of assisting depreciable capital expenditure through tax credits when compared with alternative resources used in waste treatment like land, labor for operation and maintenance, labor for more careful control of production processes, chemicals used in operation, and investment in new productive facilities that produce less pollution. The first point to make is that, in general, assisting mechanical and structural investment through accelerated depreciation or tax credits influences the firm to choose waste treatment methods that use relatively more of the assisted resource than it would have chosen without the assistance. The question is whether the firm really has any range of choice, whether there are alternative ways of treating its wastes so that this bias is harmful.

Bias produced by tax incentives does seem to be important in terms of the resource discussed in the example above, land. Many kinds of industrial waste can be treated by letting them stand in settling ponds (see Land Intensive Methods below). The fact that most tax schemes bias firms against using land is an important disadvantage of such incentive proposals. The incentive situation is similar for waste abatement procedures that have relatively high operating costs. Chemical precipitation, for instance, requires large outlays for chemicals. In addition, it appears that much abatement can be obtained through more careful management of existing facilities. In both these cases, tax incentives tend to bias industrial decision-makers away from the least expensive method toward methods which make maximum use of the kinds of capital facilities that would be eligible for special treatment under the incentive program.

One additional bias is also important. In many industries, the least expensive way to abate pollution is not by placing special devices at the end of the line to treat wastes, but rather by modifying the process in the plant in the first place to see that less waste is produced (see Potentials for Process Change below). If the tax law gives special treatment only to facilities designed directly for pollution control, it discourages businessmen from using the abatement alternative of making process changes, because investment to accomplish such changes is not subject to special tax allowances. It is at least possible that providing a very heavy subsidy to treatment facilities would lower the incentive to process change sufficiently so that enough extra waste would be produced to offset the increase in treatment capacity resulting from the subsidy. In that case, the subsidy would result in expanded treatment facilities and the diminished process change that would produce less improvement in water quality than would have taken place without subsidies. Any attempt to correct this difficulty, that is, making process investment allowable under the law faces heavy administrative difficulties.

It would be difficult to determine how much of the new equipment that resulted in lower pollution was to be given the special tax treatment for pollution-control investment, and how much of it was simply new equipment for production to be treated as such under the tax laws.

In addition to influencing the choice a manager will make about what treatment techniques to use within his plant, tax incentives distort his decisions either to treat his waste himself or to have it treated by a municipality or other government agency. This latter alternative has much to recommend it in terms of potential economies. However, extensive tax incentives for capital facilities might make them cheap enough, after taxes, for the firm to prefer to invest in its own facilities rather than have its waste treated by a central agency, even though before taxes the service charges for central treatment were lower than the cost to the firm of constructing its own treatment plant. If the service charges reflected the real costs to the central agency of treating the wastes of the plant, then again the country would have used more real resources than necessary to achieve its pollution control objectives.

Thus far we have found 1. that tax incentives do not seem likely to encourage firms which would not otherwise have done so to act, and 2. that they encourage those firms who do act to do so in an economically inefficient manner that wastes the country's real resources. The next general question to consider is whether firms should be given these kinds of assistance at all.

tax incentives and the cost burden of pollution abatement

For years now, polluting firms have been imposing costs on the users of streams and rivers in the form of the wastes they add to the water. These wastes interfere with recreation and make it unpleasant for all who encounter the dirty water. When someone argues that the country as a whole ought to pay for cleaning up the stream, he is in effect declaring that the polluting firms have a property right in the stream to dump wastes and that they should be compensated for cleaning up. Whether the Congress and the people find that argument convincing is up to them to decide.

Who does benefit from dirty water? The answer is, the individuals who purchase the products produced in the course of generating pollution. At the moment, such customers do not pay for the "external" costs they impose on others, although they do pay for the direct costs of the labor and materials used in making the product they buy. The logic of economic efficiency indicates that in the long run consumers have to pay prices that reflect the real total costs to society for producing the goods in question. This means that in the interests of economic efficiency, consumers should pay enough for products that producing firms can clean up the pollution which developed in making the products. This assumes that water quality standards which firms have to meet are established such that the costs of cleaning up the stream are equal to the benefits for the marginal dollar spent on abatement. The implication of this whole argument is that the prices of goods that lead to pollution ought to rise enough to allow firms to control that pollution. What happens when we give firms government aid to abate pollution? To the extent we give firms aid, their costs and prices go up less than the real costs to society of the pollution they generate. Hence consumers will face prices that do not reflect the real costs of the product — direct and indirect. In short, the general objection to having the government assume the costs of industrial pollution control is that it undermines the functioning of the market pricing system which leads to economic efficiency.

If the government feels nonetheless that it wants to give aid for pollution control, there is much to be said in favor of the notion that only old plants should receive such assistance. The owners of any new plants should be fully aware from the beginning of the need to abate their pollution. However, some argument can be made that current owners are being surprised by a sudden expense. The last argument admits that current plant owners have some right to pollute, but the view is in any case more reasonable for old plants than for new ones. Limiting aid to old plants will result in much of the aid going to industry, instead of being passed on to the public in lower prices for such plants are not the low cost producers who set prices in a competitive industry.

some administrative aspects of tax incentives

In addition to the very general objections to tax incentives, there are several direct and practical considerations which can be raised against using this particular method of furthering pollution abatement.

1. The current tax system has many anomalies, special provisions, and loopholes. There is much to be said in general against the erosion of the tax base resulting from the use of the tax system in this way rather than providing direct aid where aid is required. Allowing tax aid for water pollution will inevitably strengthen the case of a number of other special interests who have been pleading for similar favors or assistance. All such allowances are further encroachments on the basic source of corporate tax revenues. In fact many scholarly commentators and Congressional spokesmen advocate closing existing loopholes rather than adding still further anomalies to the current tangle of special treatment under the tax law.⁵ These considerations are an additional reason to avoid the tax route, if some aid to industry is considered desirable for pollution abatement.

2. Another strong objection to tax incentives is that once the provision is written, Congress no longer controls how much aid is actually given, as it can for direct grant programs. At the moment it is still uncertain how much will be spent for pollution abatement. In part this uncertainty results from the fact that it is just not clear exactly how much it will cost to abate the pollution from a given industrial process. Further, as is argued elsewhere in this report, (see Central Treatment Organizations, below) the amount needed to control pollution could vary tremendously depending upon whether certain potential economies of large scale plants and advantages from manipulating the natural hydrology of rivers are utilized. Thus a tax incentive

commits the country to an uncertain sum of assistance. Contrast this to a direct grant program which is a specific sum easily and precisely manipulated by Congress through annual appropriations in response to changing circumstances. An example of this flexibility is to be found in the current municipal grant program for sewage treatment plants. This program has received appropriations less than half the initial authorizations. In part this cut-back is the result of money becoming scarcer than was envisaged at the time the legislation was first passed. It is difficult to see how the burden to the budget of a special tax program could be manipulated so easily — if at all — since the ultimate result is out of Congress's hands.

3. An additional and important objection to tax incentives is that the full impact of the program on the Federal budget is not made explicit and public from year to year. Only if the costs of achieving stream standards are known, can a national examination of costs and benefits be made to see if they are too high or too low. With a tax scheme, the costs are never apparent and rational choice of standards is made that much more difficult.

4. Tax incentives will only help profitable firms. Moreover, such incentives provide more aid to firms paying the higher rate of corporate income tax than to small firms paying the lower rate. Thus tax incentives give the least help to the section of industry which needs government aid most.

5. One of the basic objections to any tax incentive is that it does not encourage firms to take account of some of the most important potential economies in waste treatment. Among these economies are those associated with very large scale plants, and with the manipulation of waste loads in response to river characteristics. Central treatment authorities which could take advantage of such factors are discussed later in this report. If anything, tax incentives encourage firms to construct individual (and therefore inefficient) treatment plants. If a central authority is seen as a long-range solution, tax incentives offered today will help create exactly the kinds of inefficient capital facilities such an authority is designed to avoid.

It is appropriate here to again point out that any significant tax incentive might well imply very high costs to the government due to foregone corporate tax collections. In light of the arguments already presented in this section, even a very significant tax concession seems unlikely to have much effect on firm behavior, and a small one seems little more than wasted money. Since so many areas of government are short of funds because of the international situation, an expensive incentive program should only be undertaken at this time if it promises very substantial benefits.

A. In general it would appear that no broad-based tax incentive is justified. Such an incentive seems unlikely to attain water quality objectives, likely to distort efficient choices, to interfere with adjustments in the price mechanism reflecting the cost of pollution control, and to impose uncertain and uncontrollable costs on the government at a time when resources are extremely scarce. In addition, it is argued below that of all general incentives, taxes are inferior to loans or grants, suggesting that if some incentive is desired, the tax approach is in general the least desirable way to proceed.

B. If despite this, Congress decides upon a tax incentive, there is much to be said in favor of limiting its impact to plants already in existence.

C. In order to counteract incentives to delay, there is much to be said for sharply limiting any tax incentive program to a specific number of years (say five) insisting as a matter of policy that no further aid will become available. Otherwise firms have an incentive to delay in order to receive more generous aid in the future. The argument for using a short term tax incentive to accelerate industrial response should be weighed against the realization that if central treatment authorities are created in the long run, capital facilities created now in response to tax incentives will burden such agencies with just the sorts of inefficient capacity they were designed to avoid.

D. At the very least, tax assistance should be limited to facilities which will bring the firm into compliance with water quality standards.

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E. In order to limit the distortions discussed above, the incentive credit route seems preferable to the accelerated depreciation method. Accelerated depreciation helps assets according to their depreciable lives — offering more aid for longer-lived assets. This additional bias could just as well be avoided. Investment credits might also be made available for investment in land for pollution abatement purposes, an option not opened to accelerated depreciation.

F. In order to minimize the lack of information and the uncertainty associated with any tax incentive, the Treasury should be directed, if a tax incentive is decided upon, to present annual statements to Congress as to how much the aid is costing the Federal government in lost tax collections.

direct grants to industry

Many of the considerations applicable to tax incentives also apply to direct grants to provide incentives for industrial pollution control. The following is a summary of the three primary points which argue strongly against direct grants just as they did against tax incentives. 1. Unless the government is willing to assume a very substantial share of the costs of pollution abatement over and above the share of the costs already underwritten by the current tax laws, it is difficult to see how a cost sharing grant will change industrial behavior. Pollution control will remain a big net loss and there will still be substantial incentives for firms to delay, awaiting new technology, more aid, or less enforcement pressure. 2. Cost sharing grants which are tied to the costs of specific capital facilities have substantial adverse effects on the efficiency of the nation's pollution abatement program. Capital grants also lower the incentive to a firm to engage in process changes to lower its pollution load. Such grants also discriminate against methods which rely more heavily on operating expenditures. 3. Direct grants will result in lower prices for goods whose production results in pollution than the prices that would reflect the costs of abating pollution. Thus consumers will not face prices that reflect the real costs to society of the goods they buy, and economic inefficiency will result. 4. Government grants for firms to construct their own treatment facilities make it less likely that a firm will agree to have its wastes treated by a government agency for a price that reflects the real costs of the treatment. Even if self-treatment is more expensive at market prices, it appears to the firm to be less expensive to treat its own wastes (with the help of the grant), than to go along with central treatment. However, the latter might in fact be more efficient from society's point of view. Some of this difficulty could be avoided by making such grants available to a firm to pay for some of its share of the construction costs of central treatment plants.

However this argument assumes that there is not already a significant bias in favor of central treatment. In fact, as is discussed below, the current Federal grant program for municipal facilities does contain very significant incentives to firms to engage in such joint treatment even where it is not economical to do so. Later in this report the strong recommendation is made to eliminate that bias. But if the bias is not eliminated, a grant program for industrial capacity might serve to counteract an existing bias rather than create a new one. 5. There are certain kinds of grant programs which would affect firm behavior in desirable ways, although they are probably politically unfeasible. For example, consider a grant for 100% of the costs of providing storage ponds or for treatment facilities that move a firm beyond the levels required by current enforcement standards. These grants would have some real social benefits in terms of water quality, unlike the grants that have actually been proposed. There is no point in a grant that covers a small fraction of the costs of treatment plants that firms will have to build in any case to avoid enforcement penalties, plants which they are also most unlikely to build more quickly because of the small grant inducement.

Despite similar drawbacks, grants have the following advantages over tax incentives from the viewpoint of public policy:

1. The amount of funds committed to the program is both known in advance and under the direct control of Congress. Funds are necessarily appropriated each

year after review of the programs. Hence a grant program allows Congress more flexibility in adjusting to changing circumstances.

2. It might be possible to make operating expenses, and costs, etc., eligible for grant assistance while it would be difficult or impossible to do so through the tax laws. Hence a good grant program could have fewer adverse effects on economic efficiency than the usual tax incentive proposals.

3. Grant assistance is not limited to profitable firms as are tax incentives, nor do grants necessarily provide less aid for small firms paying the lower corporate income tax rate.

On the other hand, grant programs have several disadvantages not shared by tax programs. First, since they relieve the government of the uncertainty of knowing how much the program will cost, grant programs shift some of the burden of that uncertainty to firms eligible for grant assistance. Since it is difficult for Congress to predict how much will actually be spent by firms for pollution abatement, it is difficult to be sure exactly what percentage of the costs of abatement would be underwritten by the amount actually appropriated for a grant program in any given year. The current municipal grant system has gotten into exactly that kind of difficulty. The subsidies actually being given are much less than the statutory maximums. In this situation, a firm would have substantial incentive to delay until it thought that the full potential amount of the subsidy were forthcoming. A grant program which promises more than it delivers (that is, whose appropriations are inadequate to provide funds for all eligible recipients) may be worse than no program at all. It may actually retard the rate at which treatment facilities are constructed. Such an outcome is not unlikely given the basic political situation within which water control legislation is created. When legislation for the creation of water quality programs is under consideration, the attention of the country is focused on the need for clean water. At such times there is significant political pressure to approve generous programs as witnessed by the unanimous passage of both Houses of the Water Quality Act of 1966. However, when it is a matter of appropriating money, the focus of legislative attention often shifts to economy in Federal spending, especially at a time like the present when funds for vital federal programs are very scarce. Whenever a general budget cut is necessary, the likelihood arises of having promised more in a grant program than is actually given, with serious consequences for the pace of pollution abatement.

Another comparative disadvantage of grant programs is that they would require a new agency and new reporting systems, while a tax system could use the existing facilities and staff of the Internal Revenue Service. For this reason, a grant system might have higher administrative costs, even though a tax system might require the F.W.P.C.A. to certify individual facilities. Both alternatives cause a heavy administrative burden. Such costs, of course, depend mainly upon the number of grants, not their cash value. Therefore, administrative costs would become especially significant relative to the size of the aid to any given firm if the actual cost-sharing percentage turned out to be low. Some aid percentages in practice in the municipal program have been very low indeed. In addition, there would be great difficulty in deciding how to allocate the funds if insufficient money were available to give everyone the statutory percentage of assistance.

A. Despite some difficulties compared to tax incentives, the grant approach seems preferable to the tax approach if Congress chooses to give some general industrial incentives.

B. Nevertheless, it does not seem that direct cost sharing for the bulk of industrial firms is justified. Such a program would have the following disadvantageous effects on efficiency; high administrative costs, low probability of offering positive incentive, and the possibility of increasing a firm's incentive to delay while lowering its incentive either to engage in efficient process changes to abate pollution or to join in a government treatment system.

C. If grants are given, however, it is desirable that they apply to more than simply the capital costs of machinery or building in order to minimize the extent to which

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they could foster inefficient decisions. In particular, grants should include the costs of land. If the land is already owned by the firm, the total value of the treatment plant on which the subsidy is based should include an estimate of the value of the land-intensive method like ponding or irrigation which is utilized.

D. Given the incentives to delay inherent in a grant program, any program should be structured to end in a relatively restricted period of time. The clearly-stated policy of the government should be to provide no additional assistance beyond that point.

E. As with taxes, there is much to be said for limiting the application of the program to those plants already existing when the program is instituted. It can be argued that some compensation is due an old plant for what is taken away when the plant is required to abate pollution, i.e., the right to pollute. In some sense, the plant's owner assumed this right when he committed his capital to build the plant. It is hard to make such an argument for a new plant, however, for the owner should know when he builds that the right to pollute no longer exists.

F. To provide some incentive for compliance, grants should be limited to abatement programs which will make plants adequate under pollution abatement standards.

G. It is desirable for any grant program that Congress try to set percentage aid levels that firms can realistically expect to be approximated by actual appropriations (unless circumstances have changed considerably in the meantime). It is poor policy to fail to meet the level of aid set. Changing circumstances perhaps explain the recent developments in the municipal program, but such a situation is to be avoided if at all possible because it substantially increases the incentive to delay until available funds come closer to statutory limitations.

H. Firms should be able to use any grants to help pay for their share of the costs of any central treatment system they choose to participate in.

One further point is that direct grants to industry ignore the very significant possibilities of exploiting economies of scale which are available to central treatment organizations. Direct grants also provide no incentive to utilize the implications of river hydrology which central organizations can take advantage of for efficient pollution abatement. The numerous advantages of central treatment schemes (see Regional Water Quality Agencies below), argue against using a device like direct grants which operate through individual industrial firms, ignoring larger possibilities.

government loans to industry

Unlike a grant program, or a program of tax incentives, a government loan program ultimately requires that the firm, and its consumers, bear at least some of the costs of pollution abatement. The value to the firm of having the use of the funds over the period of the loan could be anywhere from less than 20% to more than 50% of the value of the loan — depending on the terms of the loan and the value the firm placed on money (the firm's discount rate). This benefit is over and above any savings in interest the firm might be able to obtain from government loans at interest rates below market rates. Several points of comparison can be made between government loans and the previous two incentive approaches that have been discussed.

1. First, because a loan does not provide as much of a subsidy to the firm as a grant for the same amount, a dollar in loans does not distort the relative prices of final goods in the long run to the same extent a dollar in grants or tax incentives does.

2. On the other hand, if loans are restricted to certain kinds of capital facilities, they distort a firm's choice among alternative methods of pollution abatement. (This was also true of tax and grant incentives.) However, unlike grants, but like taxes, it would seem difficult to create a loan program that was not restricted to capital costs, as opposed to operating and maintenance expenditures. On such grounds, a less restrictive grant program would be preferable.

3. Like taxes and grants, loans lower a firm's incentive to engage in internal process changes if they are not given for such process changing investment. It is difficult to see how they could be given for such investment because of the administrative difficulties involved in determining what part of the investment was for pollution abatement and what part for enhancing the firm's profits. However, dollar for dollar, loans do provide less distorting impact on the incentive for process change than either of the other two methods. This tendency for less distortion is also true of the firm's option to participate in a central treatment system.

4. Compared to tax incentives, loans share with grants the advantage of being under the direct control of the Congress. The amount of funds available could be decided annually and explicitly — unlike a tax scheme where the actual impact on the Federal budget depends in large part upon what firms actually do, and hence is uncertain and not directly controllable.

5. Another advantage over tax incentives is that loans, like grants, could be used by firms without profits. Furthermore, firms paying the lower corporate tax rate are not discriminated against as they are in any tax incentive program.

6. In respect to high administrative costs, loans are inferior to tax incentives. In fact, because loans must be paid back, interest collected etc., this method probably has higher administrative costs even than grants.

7. Loans do have one advantage over either of the other two approaches which should be appreciated in considering alternative incentive programs. The basic virtue of a loan is that it assists a firm in raising the capital it needs for pollution control investment when it might have difficulty raising such funds on the open market. Such funds can be made available to firms at lower than market rates. The government assumes some of the risk of default but insures itself by spreading the risk over a large number of loans.

Difficulties in access to capital markets are not universal among firms. Many large corporations will no doubt be able to acquire the capital for pollution abatement investment through ordinary market channels at a similar rate of interest as that on a government loan. Consequently, if there is a loan program at all, there is much to be said for restricting it to firms which might otherwise have difficulty raising funds. One way to do this without complex administrative procedures is to set the interest rate on such loans at or near the market rate. Then firms which could borrow at the market rate would not apply. Although it has serious difficulties, a restricted loan program is one of the first incentive schemes we have considered which at all promises to do what an incentive is supposed to — namely, change behavior. If by restricting eligibility to smaller, poorer firms, loans could be offered that were a significant percentage of costs, such firms might be more able (and therefore more willing) to proceed with pollution abatement.

8. In light of the argument just made in point (7) we should point out that a general loan program would be open to the objection that much of the money expended would be wasted by failing to alter firm behavior. Those firms with access to the capital market already are unlikely to change their attitude to pollution-abatement investment because of a marginal change in the rates of interest on such loan capital. The important potential for loans is in assisting those firms which would have difficulty in raising the capital if it were not for the loan program.

9. It is also necessary to consider the contribution of a loan program to other national goals. One of these is increasing production and the rate of growth. There is a presumption that high return investment opportunities which cannot be exploited because of lack of capital are more common among firms that lack capital and access to capital markets than those that can borrow freely. Thus the increase in production (reflected in the return on investment) that results from a loan program is likely to be greater for loans made at higher interest rates or for loans made to small firms or firms able to show that they cannot obtain money elsewhere.

10. However, because the greatest improvement in stream quality per dollar invested results from investments in large treatment plants, care should be taken in establishing an incentive program limited to small treatment plants. The improve-

ment in stream quality will be much less than the apparent increase in the number of treatment plants built.

11. We should point out that the Small Business Administration already gives priority to loans for pollution abatement. However, the size restrictions on such loans, and the high administrative costs they impose on the firm who must demonstrate an inability to get funding elsewhere suggest that a somewhat more flexible and opened-handed program would be desirable if the loan route were chosen.

A. Loans are preferable to both grants and tax incentives as an industrial incentive, primarily because they promise to have much less distorting effect on economic efficiency in carrying out the nation's pollution control program.

B. It would be desirable to restrict any loan program to the class of firms that would otherwise have difficulty raising the capital to undertake pollution investment. The notion is discussed again later in this report in the section on hardship cases, for it is often in such cases that firms would have difficulty raising capital.

C. An unrestricted loans program would give substantial funds where it would do very little to affect firm behavior — that is, to firms with normal access to capital markets. Hence, an unrestricted loan program is not recommended.

D. As in the case of tax incentives or a grant program, there is much to be said for limiting a loan program to existing firms, for limiting it to a specific number of years (like five), and for limiting it to pollution control projects which will bring the firm into compliance with water quality standards, although the administrative costs of the latter restriction may be high enough not to warrant its inclusion.

In closing this section we should note once again that a loan program ignores the economies of scale, and the advantages of manipulating river hydrology which a central treatment agency could take advantage of. Thus while loans to small, marginal firms (hardship cases if you will) are perhaps in the public interest, such a program alone will not allow the nation to abate its wastes, industrial and domestic, in an efficient manner.

the municipal grant program as an incentive to industry

Although it is impossible to say exactly, approximately one fourth of industrial wastes are currently being treated through municipal and other government agency sewer systems like county and special sewage districts.⁶ Insofar as industries participate in such systems, aid to these systems can and should be seen as an important if indirect aid to industry to abate pollution. At the moment plans have been proposed in Maryland to tie almost all major industrial polluters into government systems of one kind or another.⁷ In many other areas as well many firms have recently begun treating their wastes jointly with municipalities first to take advantage of Federal construction grants available to the municipalities, and second to utilize the municipalities' lower interest costs due to the tax exempt status of interest on municipal bonds.⁸ Since it has been argued previously in this report that grant aid should not be given directly to industry, it is necessary to consider now first whether such aid should be given to municipalities for their domestic sewage, and then whether it should be given to construct facilities to treat industrial wastes.

aid to municipalities for treating domestic waste

Before discussing the desirability of Federal assistance for municipalities there is one important point about the current municipal program, no matter how it is financed, that must be made. Since aid is given to capital facilities, municipalities and other local treatment agencies are encouraged to build very capital-intensive facilities. Perhaps this incentive helps explain why the ratio of operating and maintenance costs to capital costs is so much lower for municipalities than for industrial waste facilities.⁹ Municipalities get aid only for capital expenditures. There are cases where poor operation has led to municipal treatment plants running far below their po-

tential, or instances of plants that fall into disrepair in an unreasonably short period of time. Perhaps some aid for municipal operating costs as well as for capital expenditures should be considered. Related to this point are suggestions made later in this report for increased federal efforts in the training and recruitment of sewage treatment plant operators. Such efforts to facilitate the supply of operators will also serve to counteract some of the capital-intensive bias in current government programs.

There are several arguments that can be made for Federal assistance for that part of sewage treatment capacity which is used to treat domestic wastes. It is important to review these arguments in order to be able to decide whether similar ones do or do not imply that such aid ought to be given as well for municipal treatment of industrial wastes.

1. Suppose the alternatives for financing sewage treatment capacity for domestic wastes are a. Federal taxes, b. state and local taxes, c. sewage charges on domestic users. The first point to consider about such options is that the Federal tax system is the only one that is not regressive in its impact. State and local taxes, especially property taxes and sales taxes, take a larger proportion of the income of poorer people than they do of the income of the more well to do.¹⁰ Sewage charges on domestic users through the water bill is an even more regressive system because it amounts practically to a head tax — that is, everyone pays the same amount no matter what his income. It is even more regressive than a poll tax because children as well as adults are charged. Against this last point it can be argued that user charges are appropriate at the municipal level, and that we can leave it to the Federal tax structure to deal with any equity or redistribution questions. But this last approach avoids the responsibility a policy maker must assume for the actual, as opposed to theoretically possible, impact of his choices. Thus the greater progressivity of the Federal tax system can be seen as a point in favor of its use in this instance.

2. The above argument is much reinforced by noting that many of the benefits of clean water accrue in greater amount to the relatively rich than to the poor. (See Table III). Similarly, in recent public opinion polls, upper income groups are more concerned than lower income groups about clean water.¹¹ This seems natural in that benefits from clean water such as outdoor recreation, boating, and fishing, are often luxury items. Thus financing clean water by user charges on domestic waste would be in effect to redistribute income from the bottom of the ladder to the top. The poor would pay more and the well-to-do would get more of the benefits.

Relationship Between Income and Frequency of Engaging in Specific Activities

Percent of group who engaged in activity often
(5 times or more in last 12 months)

Income group	Outdoor swimming or going to a beach	Boating and canoeing	Fishing
Under \$3,000	10	5	17
\$3,000-4,999	22	9	20
\$5,000-7,499	32	15	23
\$7,500-9,999	38	16	20
\$10,000 and over	47	22	19
All groups	26	12	20

Source: Eva Mueller and Gerald Gurin (Survey Research Center, University of Michigan), Participation in Outdoor Recreation: Factors Affecting Demand Among American Adults. Report to the Outdoor Recreation Resources Review Commission study report 20 (Washington: U.S. Government Printing Office, 1962), p. 12.

**Participation in Selected Outdoor Activities
by Family Income. Percentage of Persons
12 Years and Over, June-August, 1960**

Percentage of persons 12 years and over participating

Income group	Boating	Fishing
Less than \$1,500	4	24
\$1,500-2,999	9	24
\$3,000-4,499	19	28
\$4,500-5,999	24	32
\$6,000-7,999	28	32
\$8,000-9,999	33	31
\$10,000-14,999	41	39
\$15,000 and over	36	27

Source: U.S. Outdoor Recreation Resources Review Commission, National Recreation Survey, ORRC study report 19, quoted in U.S. Outdoor Recreation Resources Review Commission, Outdoor Recreation for America, a Report to the President and to the Congress (Washington: U.S. Government Printing Office, 1962), p. 38.

3. It can also be argued that the state and local sectors are harder-pressed for funds than the Federal sector, and therefore the Federal tax system should bear the burden of financing sewage treatment investment. On the Federal level we have had tax rate reductions and some taxes abolished in recent years. This is in sharp contrast to the situation at the state-local level which has seen steadily rising tax rates and the introduction of new taxes in many states to meet the expanding obligations of state and local government.¹² There has also been much discussion of rebates from the Federal government to the cities or states for financial assistance.¹³ This too is an argument for Federal assistance.

4. If we place the burden of financing some part of industrial waste treatment on local governments, it is quite possible that the pace of pollution control efforts will be slowed down. Most of the benefits of clean water from cleaning up municipal wastes do not accrue to the citizens of the city. In addition, inter-state or inter-city competition for industrial location could lead to charges below costs, with an accompanying strain on the local fiscal system.

5. Many local governments have debt limits set either by the constitutions of their states or by statute. To force the municipality to assume the bond financing burden of sewage treatment facilities might foreclose additional improvements to schools, roads and other community facilities. Given the political pressures at the local level for these other needs, funds for pollution control could be in short supply if no aid were forthcoming from higher levels of government. It is not likely that local debt limits could be easily changed to allow for sewage treatment plant construction.

6. One disadvantage of Federal funding is its impact on different regions. Those parts of the country that have had good water pollution control programs will in effect support those areas that have been less willing to clean up in the past, since it is those areas which currently have dirty water requiring a disproportionate share of Federal aid. Also under Federal funding areas which have relatively clean water not from conscious control efforts but because of low population densities will give some assistance to those areas where water is polluted because of urban agglomerations. These inequable features might be considered undesirable, but they must be balanced against the other advantages of Federal assistance discussed previously in choosing among alternative incentive programs.

**aid to municipalities
for treating industrial
waste**

Whether or not Congress intended it, a significant part of the current aid to municipalities and other government agencies is being used to construct capacity to treat industrial wastes. The question is whether this policy is desirable from the

viewpoint of the public interest. In general, as is argued below, the answer appears to be that current practice is not the best possible.

The following arguments are based on the assumption that when municipalities receive government grants for constructing capacity that treats industrial waste, they do not charge industry for its full share of the cost regardless of the grant. There are several arguments for the plausibility of this assumption. First, it is unlikely that a firm will have to pay for the costs already covered by Federal grants if the firm is an important influence in the town. Many plans for the municipal treatment of industrial waste seem most likely to be devised in just such situations to save industry some of the expense of waste treatment. Secondly, charging industry for its share of the gross costs, as opposed to the net costs, would mean that the town would build up substantial surplus on its sewage treatment accounts, since it would be charging industry for costs the town did not actually incur. Finally, if industry were being charged its share of the gross costs, there would have been no need to obtain federal aid for the industry's share in the first place, since the firm was paying for it in service charges. While we have not been able to obtain any clear information on the current situation (in part because the program is so new), it would seem likely that a negotiated settlement of sewage charges to industry is likely. Therefore it is highly unlikely that industry will come to pay for the share of the cost of municipal or other government agency treatment plants that is also covered by federal aid.

In such a situation the following seems to be true:

1. Because the industry is not paying the full costs of treating its wastes when it uses a federally funded capacity, the incentives for the firm in such circumstances to engage in process changes to lower its waste load is less than should be. For charges based on water use, as is the case, the firm enjoys no decrease in charges for reducing its waste load, when water use is not also lower. Consequently there is almost no incentive for process changes of certain types. This is a very important point since process change is often one of the most efficient ways to eliminate or limit water pollution. (See the section on Process Change below.)
2. A firm might tie into a municipal or other system even when in reality it would be cheaper to treat itself — self-treatment might be less expensive in reality because of the sewer connection required. However, if the municipality has a federal grant, it may charge the firm less than the full costs to both it and the federal government. In that case what appears cheaper to the firm is actually more expensive to society.
3. Insofar as firms benefit from subsidized treatment capacity, the prices for the products adjust less than they would if the firm had to bear the full costs of waste abatement. Consequently, consumers face prices that do not reflect the real cost to society of producing the goods they buy. The results are economically inefficient.

The Federal government clearly has some justification for being concerned with the level of service charges set by a municipality on an interstate river because, under current regulatory practice, the level of such charges will affect the eventual water quality observed downstream. The higher (or lower) the level of service charges, the greater (or less) incentive a firm has to engage in process changes. Since treatment plants are both designed and required to remove a given percentage of waste input, lower service charges to industry means that more waste goes into the plant and hence more comes out—impairing water quality downstream.

In the previous two subsections use has been made of the distinction between industrial and domestic wastes as a basis for determining which part of the waste load on a treatment system ought to be eligible for Federal government construction grant subsidy. Upon closer examination several problems appear in applying this distinction in particular cases. Most notably, how should restaurants, boarding houses, hotels, laundries etc. be treated? The suggestion offered here is based on several considerations of feasibility, equity, and efficiency. In considering efficiency implications, note that most of the establishments in question have little opportunity to make changes in internal production processes in a manner that would lower their waste loads. Thus the chief argument for not giving subsidies for industrial

the distinction between industrial and domestic waste

waste treatment facilities namely that such a policy is necessary if service charges are to be high enough to induce process changes — has less relevance in these cases. On the equity side it seems inappropriate for treatment capacity intended for the waste from a large resort hotel to receive a subsidy when the capacity for some neighboring business does not. On feasibility grounds it is also clear that including many small establishments like boarding houses or laundramats in the determination of the industrial waste load or in the sophisticated industrial service charge structure will require great administrative costs. Finally note that one of the arguments for the subsidy for domestic waste treatment capacity is the income distribution implications of such a procedure. And many of the smaller hotels, boarding houses, restaurants and laundramats act as substitutes for household facilities for the people who use them.

The implication of this set of considerations would seem to be that large waste sources like major hotels and laundries should be treated like industrial plants both for the purposes of deciding federal grant eligibility and for the purposes of assessing sewage charges. Such a procedure implies treating these businesses equitably compared with other businesses. On the other hand, small service operations like boarding houses and laundramats probably should be treated as part of the domestic sector. This procedure treats the persons using such facilities equitably compared with other citizens. Also it is administratively desirable since a few large waste sources will have to be examined but not many small ones. Charges for large operations also do provide some incentive to process changes to those businesses in the service sector which might have some scope for such efficiencies like large laundries.

Clearly the procedure suggested will have difficulty dealing with some ambiguous cases. But this is the problem faced by any administrative rule that attempts to draw a precise distinction in a world without precise distinctions. The suggestion made here is just that, a preliminary result of an incomplete analysis of this question. Further study does need to be undertaken on this point.

conclusions and recommendations

Because of the advantages of regional or river basin water quality authorities, there are strong reasons for recommending that much of the current municipal grant program be redirected through such authorities. (See the section on Regional Water Quality Authorities below where this argument is developed.) However, if such a redirection is not undertaken, the following recommendations can be made for reshaping the existing municipal grant program.

1. For the reasons just given it does not seem desirable to continue to give grants to municipalities to construct industrial treatment facilities. Instead, the current practice should be changed so that grants are only given for that percentage of capacity which is actually used to treat domestic wastes. Towns should be required to allocate costs between industrial and other wastes according to standardized procedures. This could be done within the current grant review process at the F. W. P. C. A. As an administrative simplification, regional guidelines could be developed indicating the typical expense for treatment per person connected to the system. These could serve to help identify cases where very significant industrial treatment was being undertaken.

2. It is argued elsewhere in this report (see Regional Water Quality Authorities) that there are very substantial economies to be derived from large treatment plants because of the technological nature of waste treatment. Therefore, industry should have substantial incentive to join municipal or other central systems, because the real costs of treatment in such systems are very often less than the costs of providing for its own waste abatement.

We have also argued below that regional organizations offer still further advantages in that they can exploit the particular characteristics of a river and hence attain a given level of water quality at much lower cost than a series of individuals acting alone. Thus it does not seem necessary to give indirect inducement also to industry to join such systems.

3. Grants to municipalities should be made conditional on their demonstrating that they have industrial service charge schedules sufficient to promote industry's assuming the cost for treating its own waste.

In order to pull together and clarify everything that has been said in this section the following summary is offered of some of the main points in the argument and the conclusions they imply. This is not, however, a complete repetition of all the points made previously.

general summary and conclusions on fiscal incentive

1. For a variety of reasons, no across-the-board general fiscal incentive or subsidy to industry seems justified.
2. A restricted loan program for firms which would otherwise have difficulty gaining access to new capital for treatment facilities is the least objectionable scheme considered. Such a program might assist in achieving national water quality goals.
3. If a general incentive scheme is decided upon contrary to the recommendations of this study, both direct grants and loans are preferable to tax incentives, with loans being the more desirable. Also, any such general incentive should probably be limited to existing firms. It should expire in a set number of years with the clearly stated policy that no further aid will be given.
4. In designing any aid program, the goal should be to assist the widest possible abatement techniques in as even-handed a manner as possible to limit distorting effects. The costs of land for land intensive methods particularly should be included as well as some assistance to municipalities for operating and maintenance costs.
5. The current municipal grant program should be restricted to facilities for treating domestic wastes, and made conditional on demonstration that industrial wastes are treated for a service charge based on the full costs of such treatment. It is argued later in this report that, where possible, much of this grant program should be channeled through regional water quality authorities.

¹ "Views of the Governors on the Tax Incentives and Effluent Charges (Water Pollution Control and Abatement)", Twenty-first Report by the Committee on Government Operations, U.S. Government Printing Office (Washington: 1966) Appendix G.

² The flow of depreciation write-offs from an investment has different value to the firm depending on the life of the asset, the firm's discount rate and the method of depreciation utilized for tax purposes. Operating expenses can simply be charged against current income in the year they are incurred.

³ "Views of the Governors on the Tax Incentives and Effluent Charges," op. cit. Appendix G and Congressional Record, Senate, April 6, 1966.

⁴ Several court cases have held that various kinds of earthworks are depreciable, for example: dams; Quito Electric Light & Power Co. 10 BTA 538 (1928) and Union Electric Company of Missouri 177 F 2d 269 (1949); canals, Quito Electric Light & Power Co. 10 BTA 538 (1928); sewers and water mains, Algernon Blair 29 TC 1205, at page 1221 (1958); and earthen dams, Ekberg v. United States 60-1 USTC 9332 (D.C.-S.D., 1960) reviewed on other grounds 291 F 2d 913.

⁵ See Hellmuth, W. "The Corporation Income Tax Base" Tax Revision Compendium, Vol. I, page 283, Committee on Ways and Means, November 16, 1959; who gives references to the extensive literature on the subject.

⁶ "The Cost of Clean Water," op. cit. Table 8.

⁷ "A Prospectus, Water Pollution in Maryland," The Report of A Study Commission to Investigate the Problems of Water Pollution Control, Baltimore, mimeo, Feb. 21, 1967.

⁸ Conversation with Mr. Peloquin of the New England Water Pollution Control Commission on October 3, 1967 and with Mr. James B. Coulter, Chief Engineer of the Environmental Health Service of the Maryland Department of Health which took place on October 13, 1967.

⁹ Cost of Clean Water, op. cit.

¹⁰ Bishop, The Tax Burden by Income Classes, National Tax Journal, 1961; Special Report on the Allocation of Tax Burdens and the Benefits of Government Expenditure by Income Class, The Tax Foundation, 1966; Musgrave, R. A. and Daicoff, Who Pays the Michigan Taxes, Staff Papers, Michigan Tax Study, 1960.

¹¹ From the Roper Polls instituted on March 31, 1965 and June 2, 1965, the following information was obtained:
Question 1: How would you beautify America? (June 2), one alternative reading, "water pollution, clean up rivers, lakes, streams."

Question 2: Which of three national problems should the government devote most of its time to? (March 31), one alternative reading, "Trying to reduce pollution of air and water."

Income Level	Question 1	Question 2
less than \$5,000/yr.	24 = 1.7%	88 = 5.3%
\$5,000/yr. greater than \$5,000/yr.	1462	1667
	167 = 12.5%	418 = 24.5%
	1329	1712

¹² Break, George F., Intergovernmental Fiscal Relations in the United States. The Brookings Institution, 1967, esp. p. 3 ff.

¹³ For example, see Heller, Walter, New Dimensions in Public Economy, Harvard University Press (Cambridge: 1966).

**stream
hydrology
and its
implications**

In order to provide a viable water pollution control program, policy makers should understand the implications of stream hydrology for obtaining a given water quality at minimum cost.¹ The harmful effects of pollutants will depend on conditions like volume, temperature, and rate of water flow of rivers into which they are discharged. The discussion in this section will concern the very significant aspects of stream hydrology which must be considered in attaining the nation's water quality objectives at minimum cost.

Pollutants can be classified as 1. "conservative" and 2. "organic" or "bio-degradable." "Conservative" pollutants, including most inorganic solids, do not decompose in water. The concentration of these pollutants is inversely related to the volume of stream flow, so that, for a given quantity of pollutant, the greater the flow, the smaller the concentration of the pollutant in the water. The problem with most conservative pollutants is that they are toxic, corrosive, or unsightly. For example, sodium chloride, from oil well brines, lends an unpleasant salty taste to drinking water and corrodes water pipes.

"Organic" or "bio-degradable" pollutants are in many cases the primary focus of efforts to maintain water quality. The essential problem with these substances is not that they are toxic or unsightly in themselves, but that they decompose, using the oxygen dissolved in the stream in the process, and producing carbon dioxide and water as by-products. (The oxygen demand exerted by organic matter is measured by standardized tests, and is known as the "biochemical oxygen demand," often abbreviated BOD). The BOD in a stream is not itself an object of concern, but it must be considered in relation to the dissolved oxygen concentration in a given stream. (This concentration is measured in parts per million, or "ppm.")

The level of dissolved oxygen in a stream at any given point is the result of a dynamic balance between two opposite forces. The BOD in the stream, both from pollution and natural sources, removes the natural oxygen by using it in decomposition. On the other hand, more oxygen is continually being dissolved into the stream from the atmosphere through the surface of the water and from algae in the stream. The effect of organic pollutants is to sharply increase the demand side of this natural balance. If enough BOD is added, the result is that the oxygen is used faster than it is resupplied from the air, and the dissolved oxygen level in the stream declines.

Why should concern focus on the level of dissolved oxygen in a river? First, if such oxygen concentrations fall too low this endangers fish life. Although lower levels of dissolved oxygen will support fish, a concentration of 5 ppm is usually regarded as desirable. Second, if the dissolved oxygen content in some part of a stream falls to near zero for several days, the nature of the decay process in the stream changes. Without oxygen, the "aerobic" bacteria that usually effect such decay will be replaced by "anaerobic" bacteria. Under the latter conditions, the products of the decomposition process are odorous gases that sharply decrease the recreational and aesthetic value of the water. When a stream smells, it is because anaerobic conditions are present.

Because it is such an important aspect of policy choice, there is a great need for further research to clarify the effects of various levels and patterns of dissolved oxygen concentrations on water-way conditions.² The recent Report of the National Technical Advisory Committee on Water Quality Criteria,³ suggests that raising the minimum monthly average dissolved oxygen level in a stream much above 5 ppm yields only limited social benefits. Moreover, the normal monthly average dissolved oxygen concentration is likely to be well above the minimum level which will obtain in periods of low flow.

The level of dissolved oxygen in the water is not uniform along a river into which organic waste is being dumped. The pattern of dissolved oxygen depends upon

aspects of the nature of pollution

the interaction of several complex chemical and physical processes. Without going into technical details, the overall pattern, if graphed, would resemble a "U". Below the point where waste is being dumped, the dissolved oxygen level declines steadily as one goes downstream. Then, at a certain point downstream, the rate at which new oxygen is being dissolved surpasses the rate of depletion from the waste. From then on the dissolved oxygen concentration begins to increase. Thus the oxygen situation is worse not immediately below the point of dumping, but several miles downstream.⁴

The objective of pollution control then is to prevent the dissolved oxygen level from falling too low along too great a stretch of the river for too long a period of time. Otherwise fishlife becomes endangered and other harmful effects can occur. One area where much further research is needed is in determining more exactly what are the actual harmful effects on fish life of different dissolved oxygen levels over various time spans and for different river lengths. Lack of more complete knowledge in this area makes it difficult to specify exactly what abatement policy should be, because the impact on the ecology of various possible dissolved oxygen patterns are not yet fully known.

The most important point about all pollutants is that their effect on water quality depends on their concentration. The smaller the quantity of water receiving a given quantity of pollutant, the higher the concentration of the pollutant and the greater the danger to water quality. Therefore, differences in stream hydrology which will influence the concentration of pollutants in the water are of particular importance to the design of an efficient water pollution control program. Most of the discussion in this section will pertain to organic substances and other biodegradable wastes because most pollution problems are derived from them, and because any remarks on the efficacy of reducing effluent concentration will be applicable to conservative pollutants as well.

Since oxygen dissolves into a stream through the surface, a substantial amount of untreated oxygen-demanding wastes can be assimilated by a river without dangerously reducing the dissolved oxygen content of the water. For example, the Corps of Engineers has estimated that the assimilative capacity of the Potomac River at Washington, D. C. is 48,000 pounds of BOD per day, which is roughly equivalent to the untreated daily wastes from 240,000 people. With this pollution load the river will maintain a dissolved oxygen standard of 5 parts per million when it is flowing at 1,000 cubic feet per second and has a water temperature of 77°F.⁵

variations over time in stream capacity

There are several factors which combine to determine the impact of a given amount of pollution on the dissolved oxygen in a river. Each tends to reinforce the other to produce a rather striking result, namely that the harm done to water quality by a given amount of pollutant usually varies tremendously with the season.

The primary factors which affect the rate at which dissolved oxygen is added to a river and the rate at which BOD exerts a demand on river oxygen (and hence determine the impact of a given amount of pollution) are the volume of stream flow, the amount of the pollutant in the water, the temperature of the water, the initial dissolved oxygen content, the rate at which oxygen is dissolved into the water, and the chemical composition of the pollutant and of the water it enters.⁶

The re-aeration rate, indicating how fast oxygen is dissolved into a body of water, increases with larger surface area. For example, for a dissolved oxygen level of 5 parts per million, at 77°F, the assimilative capacity of the Potomac River is 48,000 pounds of BOD for a flow of 1,000 cubic feet per second. The capacity increases to 340,000 pounds of BOD, over 7 times as much, for a flow of 5,000 cubic feet per second.⁷

Variation in temperature is also significant. An increase in temperature lowers the maximum amount of oxygen which can be dissolved into the water. This maximum

is called the saturation level. However, a temperature rise also increases the rate at which oxygen diffuses into the water (for a given difference between the level of actual oxygen concentration and the "saturation" concentration). More importantly, the rate of decomposition of organic matter, and hence the rate at which oxygen is removed from the water, increases rapidly as temperature increases. This increase is greater than the increase in the oxygen diffusion rate. Therefore, a given concentration of organic matter will cause the lowest dissolved oxygen levels when the water is warmest, usually in the summer.

For instance, the assimilative capacity of the Potomac River will differ enormously depending on the temperature of the water. For a flow of 1,000 cubic feet per second, at a temperature of 77°F, the assimilative capacity of the Potomac River is 48,000 pounds of BOD per day, while at about 35°F, a typical winter temperature, the same flow could accommodate 240,000 pounds of BOD per day or 5 times the summer capacity.⁸

Furthermore, the nature of a stream will vary with the seasons. In particular, the minimum flow in a river is generally only a small fraction of the maximum flow for the year. For example, the Willamette River, at Salem, Oregon, has a maximum average flow of 48,000 cubic feet per second in February and a minimum average flow of only 4,000 cubic feet per second in August, which constitutes a twelve fold seasonal variation. The magnitude of seasonal variation is illustrated by the fact that in this river basin, the least seasonal tributary, the McKenzie, has a maximum monthly flow of 1,945 cubic feet per second and a minimum monthly flow of 630 cubic feet per second, a difference of over 3 to 1. The Yamhill, another tributary of the Willamette, has a variation of almost 40 to 1.⁹ As noted above, the concentration of waste is given by the ratio of the amount of waste discharged to the amount of water available to receive it. Therefore, the concentration of industrial waste in a river just below an industrial outfall may vary by a factor of ten or more depending on the time of the year. Consequently, quality problems normally occur during the low flow periods, usually the summer.

The situation is further complicated by the fact that not only do the highest temperatures and the lowest flows occur at the same time of year, but fish respond differently to low levels of dissolved oxygen content depending on the season and the temperature. Since fish are cold-blooded, their activity increases as the temperature rises and thus their demand for oxygen is usually greatest in the summer when the oxygen concentration is lowest.¹⁰ High temperatures, low flows and low oxygen levels that occur during summer months combine to aggravate the undesirable effects of pollutants discharged during this period. This makes it worthwhile to explore the possibility of developing treatment approaches or administrative rules which will be able to deal economically with the seasonal aspect of the pollution problem.

In addition to the significant differences in the assimilative capacity of water that occur seasonally, a given quantity of pollutants will have very different effects on water quality depending on where it is discharged in the river. Thus, it may be more efficient, both in terms of the expenditure of resources and the resulting quality of the water, to encourage industries to locate where the assimilative capacity of a river is greatest rather than to require secondary treatment of wastes alone. For example, Crown Zellerbach recently closed its sulfite-pulping operation at Willamette Falls, where the costs of the requisite pollution abatement program were prohibitive, and supplied its sulphite pulp needs from a mill on the main stem of the Columbia River.

A decision to lower required levels of treatment on a particular river may reduce the cost of clean water in a region by directing new plants away from rivers which have dissolved oxygen or other problems to rivers whose assimilative capacity greatly exceeds the demands likely to be placed on it. There are some situations in which a dissolved oxygen problem will result even after a high degree of treat-

geographic variations in stream capacity

ment. There are other situations in which even with no treatment, a dissolved oxygen problem will not result. The point is that, on a wide, fast-flowing part of a river, no problem will arise even from considerable quantities of untreated wastes, while such a problem could arise on a narrow, sluggish tributary, even if 85% of the wastes discharged were treated.

policy implications

The strongly seasonal nature of the pollution problem implies that waste storage is often an economical way to achieve water quality standards, especially where inexpensive land is available. This is a procedure that is already commonly used for paper mill wastes along the Willamette.¹¹ By releasing any given quantity of waste proportional to the flow of the river, the concentration in each month will be the same. This proportional release results in making the maximum concentration observed in any one month as low as possible. By holding wastes and releasing them only during periods of highest flow, it is possible to reduce the annual average of the monthly concentrations still further. However, the maximum concentration observed in any one month will be higher than it would be with a strategy of strictly proportional releases. Storage and programmed releases should not be viewed only as a substitute for treatment. The efficiencies of storage discussed above apply as much to the residue remaining after secondary treatment as to untreated wastes. Any pond used for storage of organic waste will serve as an oxidation pond and provide a degree of treatment. Thus, the actual reduction in average pollutant concentration in the stream is much greater than would be expected from pure storage. (See the discussion of Land Intensive Methods above.) Storage ponds are especially cheap for industries which operate for only a part of the year. Canning and sugar beet processing are the two most important industries in this category.¹²

Where there is a problem of corrosion or cumulative poisons, the damage done by pollutants is frequently proportional to their average concentration. Sodium chloride, acids, phenols, and colored wastes are some of the pollutants for which a retention during low flow periods seems especially appropriate. For colored wastes, the current policy is to require secondary treatment now and to require further color-removing treatment processes when and if they become available. However, this strategy is producing only limited results.¹³ A strategy designed to encourage storage could lower the average color level to a fraction of the current level and a policy of complete waste storage during the summer recreational season seems the only economically feasible color control measure now available for many wastes.

Another important approach which should be considered is designing plants which are capable of obtaining high rates of removal during periods of low flow at increased operating costs and which can be operated more cheaply for lower rates of removal during the remainder of the year. One study of the Potomac concluded that the standard of five parts per million of dissolved oxygen could be most economically met by operating special treatment facilities only for the critical three and a half months of the year.¹⁴ The higher operating costs of high removal rates is economical because it only occurs for a few months and the procedure allows less standard treatment capacity to be constructed to meet water quality standards.

Another alternative to deal with the seasonality aspect of pollution problems is to have plants close down, or change processes during some critical period. For example, the problem of dissolved oxygen levels on the Willamette during the salmon run has been met by having pulp mills temporarily suspend operations during the period.¹⁵

In view of the impact of hydrological and seasonal variation on the severity of the pollution problem, it is clear that the application of simple, uniform pollution control standards, such as mandatory secondary treatment, is likely to be socially inefficient for attaining water quality goals. A given quantity of pollutants will have vastly different effects on the water it enters depending on the time of the year or the turbulence of the stream below the outfall. Thus, it is wasteful, in terms of the

opportunity costs to society, to require firms located on large, fast-flowing rivers to meet the same treatment standards as those located on small, sluggish streams. Analogously, if a given quantity of effluents threatens water quality only during the summer, it would be inefficient to require a reduction in waste loads except during the critical months. The point to emphasize is that the interests of industry and the public would both be served if the effects of seasonality were incorporated into abatement standards.

The basic conclusion of the argument above is that storage and properly timed releases can be an effective and economical tool for improving the quality and usefulness of our waters, and should be encouraged. This is not now being done. There is little provision in current rules for industry to meet the stream standards by adjusting waste discharge to stream flows, instead of performing secondary treatment or its equivalent. If a firm does provide secondary treatment, it has little incentive to provide storage in addition as a means of increasing water quality. This situation is undesirable; a real effort should be made to alter existing standards and administrative rules so that the required behavior will be expressed in terms of the polluters' effect on the stream (which is the relevant criterion) rather than through a uniform level of treatment or cutback.

There are ways seasonality might be incorporated into such standards. Abatement standards could be expressed in terms of the maximum allowable monthly average concentration of pollutants or in terms of the weighted average of the quantity of effluents discharged, where the weights were proportional to the stream flow. Either of these alternatives is preferable to a standard expressed in terms of minimum allowable treatment or maximum allowable waste loads because they are directed toward effecting an acceptable concentration of pollutants in the water. A simple strict proportionality standard however might be prohibitively expensive to implement because of the storage costs involved.

In light of this discussion, it is clear that state plans for implementing stream standards should not be rejected merely because adjustment of waste discharge to stream flow is recognized as a legitimate method for meeting the stream standards. States should be encouraged to develop plans for implementation which will lead industries to meet the stream standards by the low cost combination of treatment, storage, and other measures. In particular, when in the future a particular stream standard is not being met only during certain months of the year, industries should be required to make a reduction in waste loads only during the critical period. If the stream standards can be met by storing waste during the critical period, and releasing it later, this should be permitted as a substitute for treatment. For pollutants whose unfavorable effects are proportional to the concentration in the stream, (such as corrosive materials, chlorides, acids, cumulative poisons, and probably color) the required abatement action should be expressed as a required reduction in the contribution of each plant to the average concentration of pollutants in the stream.

These alternatives to uniform treatment standards are not without difficulties for the policy maker. In particular, storage costs will vary greatly from plant to plant. Waste storage requires land, and land may be expensive or simply unavailable, particularly in urban or hilly areas. Another reason for the variability in storage costs is that such costs are roughly proportional to the volume of material stored and are essentially independent of the volume of actual wastes.¹⁶ In other words, if one firm were to store wastes which were 10 times as dilute (and thus took up ten times as much space) as those of a second firm, it would cost the first firm almost ten times as much to store the same quantity of pollutant. Therefore, to require that the discharge of effluents be proportioned to stream flow will impose a very wide range of costs per unit of waste stored on different firms, depending on the concentration of their waste.

Because of these variations, an efficient pollution abatement program would not want all firms to undertake waste storage. Rather such storage should only be done by those plants for which appropriate land is easily and cheaply available. Indeed, to attain the benefits of seasonal release, it is not necessary or desirable that every plant adopt the same pattern of storage and release. If everyone stored completely over the summer, the assimilative capacity of the stream at the time, although low,

would not be fully utilized. Yet it is difficult to see how the desired pattern of behavior, which requires a series of complex judgments to be made, can be accomplished by current procedures, i.e. administratively created uniform behavior standards which are backed by the threat of enforcement penalties. How can a state water quality agency in the current institutional framework insist that some firms do significant storage while allowing others to do none at all? The recommendation above is that efforts be made to incorporate seasonality in current standards and some efforts in this direction would clearly be superior to the current situation. But, it is also clear that within the present approach, there are serious limitations on our ability to allow for and utilize the basic facts of hydrology in our abatement program.

One approach does offer more promise: a river basin or regional water quality authority. This type of authority would be able to relieve individual firms of the inequitable and unequal burdens (discussed above) of constructing storage capacity. It would construct such facilities itself, and support them through a system of equitable service charges to individual firms. Moreover, a regional authority would overcome the inefficiencies as well as the inequities derived from administration of even, seasonally variable standards. In order to obtain most of the benefits of scheduling waste discharges on a seasonal basis, some wastes would be stored at a few locations and released at appropriate times of the year, while the wastes from other firms would be released as they were produced and treated. Not only would this arrangement allow a regional water quality authority to utilize most of the potential economies to be obtained from flexible standards, but it would increase the number of realizable economies by eliminating inefficient, redundant or superfluous effort.

Such an authority would also have other important advantages. First, it could discharge its effluents at the optimal point in the river with respect to the assimilative capacity of the water. Treatment plant outfalls can be kept off lakes, small tributaries and estuaries. For instance, the city of Seattle, Washington, was able to reduce the quantity of effluents discharged into Lake Washington by setting up a metropolitan sewage authority.¹⁷ Second, it could control the rate of release from oxidation ponds in emergencies, such as the accidental spill of a heavy organic waste load, as well as during the normal course of the year. The point is that to schedule effluent discharges efficiently requires an integrated basin management and if society is to have clean water at least cost, there will have to be such scheduling.

summary of conclusions and recommendations

The argument presented in this section can be summarized quite briefly. Efficient pollution abatement requires that waste discharges be made in response to the hydrological characteristics of the river into which they are being dumped. The assimilative capacity of such streams varies over time and along the stream. It is important to consider the alternatives of storage, seasonal operation and seasonally used treatment capacity as methods for efficiently attaining water quality standards. At the very least, an effort should be made to incorporate such factors into current standards and administrative practices. However, the problems of efficient pollution abatement are really very complex. This situation argues strongly for the establishment of integrated river basin water quality authorities. Such agencies could efficiently schedule waste discharges, construct storage ponds, and help the country achieve its objectives without wasting scarce resources in inefficient pollution control facilities.

¹ Stream hydrology is not the same as the hydrology of lakes and reservoirs. However, since much of the pollution problem involves rivers and streams alone, that is the focus of our attention here. Conclusions reached in this discussion, however, may not be directly applicable to lakes and other large, stable bodies of water.

² J. R. Ericksen Jones, *Fish and River Pollution* (London: Butterworths, 1964) provides a summary of work to date.

³ *Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, for the Federal Water Pollution Control Administration* (Washington: June, 1967).

⁴ This pattern of oxygen concentration with distance along a stream is called the "oxygen sag." There are engineering formulas to compute this sag pattern under specified conditions. See Fair, G. M. and Geyer, J. C., *Water Supply and Waste-Water Disposal* (New York: John Wiley and Sons, Inc., 1966), Chapter 28.

⁵ U.S. Army Engineer District, Baltimore, *Potomac River Basin Report* (Baltimore: 1962), Vol. V, Appendix E.

⁶ See Fair and Geyer, *Water Supply and Waste-Water Disposal* op. cit.

⁷ Potomac River Basin Report op. cit. Vol. V. Appendix E.

⁸ Ibid., p. 571.

⁹ U.S. Department of the Interior, Federal Water Pollution Control Administration, Water Quality Control and Management; Willamette River Basin (Portland, Oregon: 1967), p. 28.

¹⁰ In special cases, other seasons of the year may be critical. For migratory fish, such as the Willamette salmon, the critical dissolved oxygen concentration occurs during migration. Or, if the water freezes during the winter, air cannot be diffused into the water and the addition of a layer of snow will block all light and prevent photosynthesis. Dissolved oxygen concentrations may reach especially low levels under such conditions and even though fish are more likely to survive low oxygen concentrations at low temperatures, this extreme situation could be critical. cf. Jones, Fish and River Pollution op. cit. p. 15.

¹¹ Water Quality Control and Management; Willamette River Basin op. cit.

¹² See U.S. Department of the Interior, Federal Water Pollution Control Administration, The Beet Sugar Industry; The Water Pollution Problem and Status of Waste Abatement and Treatment (Denver: June, 1967), and Ralph Stone and Co., Inc., Industrial Waste Profile, Canned and Frozen Fruits and Vegetables, U.S. Department of the Interior, F.W.P.C.A., 1967.

¹³ For instance, "activated sludge" removes only 10-15% of paper waste color. See Ray F. Weston, Paper Mills, Industrial Wastewater Profile, U.S. Department of the Interior, F.W.P.C.A. (West Chester, Pennsylvania: 1967), p. 68.

¹⁴ Robert K. Davis, "Planning a Water Quality Management System: The Case of the Potomac Estuary," in Water Research, Allen V. Kneese and Stephen C. Smith (ed.) (Baltimore: The Johns Hopkins Press, 1966), pp. 110-111.

¹⁵ Water Quality Control and Management; Willamette River Basin, op. cit. p. 13.

¹⁶ The major exception is that the need to maintain aerobic conditions may limit pond depth, and raise costs, for more concentrated solutions.

¹⁷ Recently a new pumping station and two-mile tunnel were opened to lift sewage out of the Lake Washington drainage basin. At the same time, two city treatment plants were closed that previously discharged into the lake; the larger of them had an average daily flow of 10 million gallons. See Municipality of Seattle, Metro Quarterly, Summer, 1967.

**the technology
of pollution
abatement**



Several aspects of the technology of waste treatment are relevant to the choice of methods for providing industry with incentives to abate water pollution. This part of the report discusses process changes, economies of scale, land intensive methods, and the possibilities of jointly treating industrial and domestic wastes.

One of the most important methods for improving stream quality is to reduce the amount of pollution which is generated. Different processes for manufacturing the same products often appear to result in significantly different waste loads per unit of product. Such process changes can often be made at relatively low cost. Similarly, better housekeeping and operating practices can often drastically reduce the amount of pollution resulting from a given process.

process changes

It is important to look at some available evidence for the possibility of industrial process changes to abate pollution, because the importance of process changes as an abatement technique is a basic element in the argument made earlier in this report against general fiscal incentives or subsidies. This discussion will include some specific industry examples, some data on the variation within a given industry on water use, and some discussion of past experience with service charges to industry.

There is clear evidence from several industries of the possibility for process change. In some cases, like meat packing, minor process modifications make major changes in wasteloads. Sweeping floors during cleanup instead of washing them down with a hose significantly lowers the total pollution load from the plant. Also, in meatpacking, there is the task of disposing of the paunch contents which weigh 60 to 90 pounds for a 1,000 pound cow.¹ These may be hauled away dry or washed down the sewer, again with different water pollution results. Further, there are several methods of rendering, or processing non-meat parts for by-products, which produce widely different quantities of waste water. Recovering blood as opposed to disposing of it as waste can produce a 45% reduction in waste load.²

Similar situations prevail in other industries. In textile and paper finishing, the choice of chemicals is important. In pulp manufacturing, the change from sulfite pulping to sulfate pulping has resulted in major reductions in waste loads. This change reduces the BOD wasteload by a factor of seven.³ In tanning, a 25 fold reduction in BOD loading is obtainable by changing from chrome tanning to vegetable tanning.⁴ In sugar beet processing, process changes can eliminate the vast bulk of pollution.⁵ By-product recovery may be an important way of reducing waste loads. For instance, in cheese manufacturing the largest waste loading comes from the whey, the part of the milk that is not made into cheese.⁶ This can be dried and used for animal feed. Additional examples can be found in Industrial Waste Profiles recently produced for the F.W.P.C.A. as well as in the standard engineering literature.

The only available attempt at quantitative estimates of the scope for process changes was made by Mr. Blair Bower and appears in *The Cost of Clean Water*, a report prepared by the F.W.P.C.A.⁷ The estimates support the belief that there is considerable scope for process change.

The importance of process change for most industries can also be deduced from the wide variance in the quantity of pollutants per unit of product which profitable firms in the industry produce. The current variation in waste loading per unit of product, in the absence of any incentive to economize on production of pollutants, strongly suggests that a small penalty for pollution will lead to large reductions in some industrial waste loads. For instance, one study of the meatpacking industry showed that the BOD loading per 1,000 pounds killed ranged from 3 to 47 pounds of BOD.⁸ If some plants were able to obtain BOD loads as low as 3 pounds without a very strong incentive to do so, firms with large wasteloads could make similar improvements. This conclusion is supported by the evidence that plants with high BOD loads also have high wastewater volumes.

Some work has been done to determine the variability of waste loads in a variety of industries, in order to indicate the potential for process changes.⁹ In a study

for the F.W.P.C.A., firms were ranked by pollution load per unit of output. From this ranking, waste load limits were computed which excluded the sixth of the firms with the highest waste loads per unit of output and the sixth of the firms with the lowest waste loads. That is, the data presented show the limits of waste production for the central two-thirds of the firms. The range in waste loads included by these limits in most cases were 5 to 1 or greater. This shows that the choice of manufacturing process can be as important as the level of waste treatment in determining the pollution load.

The final piece of evidence for the potential of process change comes from evidence available on the response of waste loads to the cost of treatment. Significant reductions in waste loads indicate the possibility for process change. One city for which reasonable quantitative information is available is Cincinnati, Ohio. In 1953, Cincinnati set up a system of industrial waste surcharges based on BOD and suspended solids. In the first year firms had the incentive of a retroactive reduction in service charges if reductions were made in their waste discharges, and firms were able to cut back their wastes by 36%, receiving refunds of \$222,000 out of the \$609,000 originally collected from 23 major companies. Reductions in waste load through process change continued in later years as firms attempted to reduce the service charges even though output increased.¹⁰

economies of scale

Another important aspect of pollution abatement technology is the economies of scale in treatment facilities. In general, it is cheaper to build and operate one treatment plant to handle a given volume of waste than it is to build two separate plants. This is not surprising since economies of scale appear to exist for virtually all chemical processes, of which sewage treatment is just a special case. To a large extent, these economies result from the fact that the volume of a tank or the carrying capacity of a pipe increases much more rapidly with size than the surface area. Since capacity depends on volume and costs depend on surface area, capacity rises more quickly than costs.

Major treatment techniques like sedimentation, activated sludge, trickling filters and oxidation ponds all involve handling large volumes of liquids, often holding them for substantial periods of time. Other economies result because the cost of items such as instrumentation, office space, laboratories and repair shops, rise less rapidly than capacity. The cost of buildings to house equipment also increases much less rapidly than the volume of equipment, and engineer's fees often decline as a percentage of total cost as plant size increases.

There are ample specific examples to confirm the general arguments made above. The recent Industrial Waste Profiles of the F.W.P.C.A. cite treatment costs for plants of small, medium and large sizes. These reports generally show substantial economies of scale. For instance, in petroleum the costs of an activated sludge process for a typical refinery are about \$8 per standard barrel of daily capacity for a small refinery as opposed to \$5 per standard barrel of daily capacity for a large refinery.

Although there is only limited empirical data on industrial facilities, the processes used are identical to those used for municipal wastes, for which good cost studies are available. All the data show significant economies of scale. One good study provides a compilation of the costs of treatment for various processes, using engineering calculations for plants of three sizes: 2.5, 10, and 50 million gallons per day.¹¹ For instance, the costs of primary treatment (three hour settling without chlorination) for each million gallons of daily capacity decline for larger plants. These costs are \$225,800 for a 2.5 mgd plant, \$171,300 for a 10 mgd plant and \$109,100 for a 50 mgd plant. The best statistical study based on the costs of actual plants is *Modern Sewage Treatment Plants, How much Do They Cost?* This study shows costs rapidly decreasing with size of plant. The data are based on analysis of observed cost data for 1,504 plants. Thus, the evidence shows clearly that the cost of constructing treatment plants declines rapidly with size.¹²

Similarly, there are large economies of scale in operating costs. These arise partially from indivisibilities in plant operation. One man can monitor several units with little more labor than watching one. Repair costs rise less rapidly than size. It does not take much more time to replace a part in a small pump than in a large one. A large plant may economize on fuel by using the methane gas produced in sewage decomposition and on electricity by generating its own electricity from the same gas. The empirical evidence confirms the existence of large economies of scale in plant operation. The authors of a careful study of 321 existing treatment plants came to this conclusion for every type of process examined.¹³

Such economies of scale have several policy implications. First, with certain exceptions, it is feasible and in some cases even desirable, to treat industrial and municipal wastes together. When this fact is combined with the strong economies of scale shown above, the advantages of having all industries and municipalities within a given area combine to construct regional treatment plants cannot be ignored.

Second, because of the existence of large economies of scale, the cost of treating the wastes of a particular plant and municipality will vary widely depending on the quantities of wastes treated. The per unit costs of a small plant may be several times those of a large one. This is one of the reasons for believing that basin-wide organizations, able to do a high level of treatment where costs are low and lesser treatment where they are high, can be significantly more efficient than requiring the same level of treatment for all plants and municipalities, regardless of their size.

In this section, several land intensive techniques of waste treatment are considered and their implications examined. To begin, the most important land intensive treatment method is ponding. This process allows organic matter to decompose out of the stream rather than in it. The primary problem in operating a pond is to maintain sufficient dissolved oxygen in the water. If the dissolved oxygen level falls to zero for a substantial period of time, oxygen demanding or aerobic bacteria are replaced by anaerobic bacteria, which are able to survive without oxygen. Some of the decomposition products of anaerobic processes have offensive odors. To prevent anaerobic conditions from developing, a pond requires a certain surface area to handle a certain quantity of waste. This is because oxygen enters an oxidation pond through diffusion at the surface and through photosynthesis due to the algae in the pond. Both of these processes are proportional to the surface area of the pond rather than to its volume. One surface acre can typically handle about 50 lbs of BOD per day, which is equivalent to the daily wastes produced by 250 people.¹⁴ Loadings can be increased by using mechanical aeration to increase the rate of oxygen transfer. The capacity also will be higher in the warmer climates where the rate of decomposition will be highest.

In addition to the actual area of land required, it is desirable to locate the oxidation ponds sufficiently far from densely inhabited areas so that if odor problems should arise, they will not affect a large number of people. Recently, considerable progress has been made on the design and operation of anaerobic ponds which show promise of being able to operate at higher waste loadings.

Another land intensive treatment method is irrigation. In western arid areas where water is scarce, this method involves using sewage effluent instead of fresh water for conventional irrigation. In eastern areas the goal is usually not the growing of crops but disposal of the effluent. The waste loadings in this process are limited by the absorptive powers of the soil. Loadings of several hundred inches per year are obtainable.¹⁵ Since costs vary with the volume of waste rather than with the total quantity of pollutants, this technology is generally well suited to handling concentrated waste. As long as water does not run off the land directly into the stream, but is filtered by the soil and enters the stream via the ground water reservoir, irrigation offers virtually 100% treatment. It is one of the few treatment processes attaining this efficiency. Another very efficient process is the non-overflow oxidation pond in which the water is finally disposed of by ground percolation and evaporation.

land intensive methods

If land is available, one of the land intensive treatment methods may prove to be the cheapest form of treatment. Frankel found that oxidation ponds are far cheaper than other alternatives where inexpensive land is available.¹⁶ For larger plants, ponds are less advantageous because of the economies of scale in treatment facilities discussed earlier. Such economies are less significant for ponds since large facilities are essentially multiple duplications of smaller ones. Similarly for industrial wastes, the Industrial Waste Profiles generally show ponding and irrigation to be cheap disposal methods.

Land intensive methods are commonly used today. Irrigation is especially common for cannery wastes, as well as other industries. In a study of 31 meatpacking plants, 9 used some form of lagooning.¹⁷ In the sugar beet processing industry, lagooning is virtually the only treatment process employed. In 1967, land intensive methods were as commonly used in the paper industry as other means of secondary treatment.¹⁸

Most existing plants were located without considering possible future needs for large areas of flat land for waste treatment. Such land is not available if current plants are located in a congested or a hilly area. Even if the farmer next door has suitable land available, an existing factory may have difficulty in purchasing it for anything resembling the going price for farmland. Firms in these situations do not have the option of using land intensive methods. However, a new plant can select its site with a view to utilizing land intensive treatment measures and can purchase the necessary land along with the land required for the plant building and parking lot.

The practical importance of substitutability between land intensive and non-land intensive treatments is that if industrial wastes are to be treated in the cheapest way possible, any subsidy system should not discriminate between these two methods. One disadvantage of the current municipal grant program, which subsidizes the treatment of much of our industrial wastes, is that it excludes the cost of land, thus biasing the selection of a treatment process away from what may be the low cost method. Similarly one of the reasons for recommending against accelerated depreciation as a subsidy measure is that land is non-depreciable under the tax laws and would not benefit from such assistance. Also, although undesirable in general, if a special investment credit is given for pollution abatement investment, it should not exclude land. One of the advantages of grants or low interest loans as a subsidy device is that no special provision is needed to make the subsidy neutral between land intensive and non-land intensive treatment measures. In particular, land costs should be included in the current municipal grant program to eliminate the current bias against land intensive methods.

There are several reasons why, if there is to be a bias, it should be toward land intensive methods. The most important reason is that irrigation, and in a few cases oxidation ponds, may provide 100% treatment.

If a subsidy leads firms to use conventional treatment instead of a cheaper spray irrigation system, society has not only paid more for the treatment, but may have greatly lowered the level of treatment obtained.

Oxidation ponds also have advantages over other techniques in operation and sampling. Aerobic ponds are relatively simple to operate and maintain. If no aeration is employed, there is not even any machinery to maintain. This means that the actual level of treatment obtained is likely to be higher for ponds than for more complex technologies. Sampling is also much simpler where ponding is used. The largest expense of a sampling program is obtaining enough samples, weighted according to flow, to determine the average concentration of the effluent of a plant. Due to the mixing that takes place within a pond, one sample of the effluent is sufficient. This greatly reduces the sampling cost incurred by any agency responsible for ensuring compliance with water quality standards.

As mentioned in the section on hydrology, ponds also provide a large quantity of storage as an incidental benefit that can be used for seasonal scheduling of waste discharge. If institutional arrangements are favorable, ponds can be operated to provide a considerable degree of storage, both during periods of low flow and for meeting short term quality problems in the river.

The existence of land intensive technologies that are very much cheaper than other alternatives where land is available implies that plants with large areas of cheap land will have lower waste treatment costs than other plants. This variability in costs is one of the principal reasons for recommending river basin authorities because such agencies will be able to provide a high degree of treatment where it is most economical.

In most cases there are large economies to be gained from treating industrial and domestic wastes together. The bulk of pollution problems involve either suspended solids or organic matter and the basic treatment processes, such as sedimentation, trickling filters, activated sludge, oxidation ponds and chemical precipitation, are the same for both. The purpose of sedimentation is to remove suspended solids which are found in both industrial and domestic wastes. The purpose of the various secondary treatment methods is to stabilize organic matter.

the joint treatment of domestic and industrial wastes

In some cases there may be economies from mixing industrial and domestic wastes in addition to those resulting from the economies of scale obtained by treating them both with the same processes. If the effect of a hot industrial waste is to raise the temperature of the mixture by a moderate amount, the rate of bacterial action is increased, thus improving treatment efficiency. More importantly, some industrial wastes are lacking in nutrients which are needed for efficient bacterial action. These nutrients can be obtained from domestic sewage. Thus, by performing joint treatment, the cost of nutrient purchase is reduced or eliminated.

In addition, if nutrients must be artificially added, there is likely to be an increase in the nutrient concentration in the ultimate effluent. Considerable effort is going into keeping nutrients out of the waters. This problem is more serious for oxidation ponds than for other types of secondary treatment, because the nutrients are incorporated into algae which pass out with the effluent. However, there are also a large number of cases in which a specific characteristic of an industrial waste, such as acidity or toxicity, interferes with the bacteriological action in a secondary treatment unit. Usually these substances, such as corrosive materials or inflammable liquids, would also be a problem in the stream and must be removed by a pre-treatment process. In general, these cases can be handled by the apparently arbitrary procedure of forbidding the discharge of the offending substances to the sewer. This procedure is usually the most efficient one, however, because the specialized treatment required is frequently cheapest when performed on the concentrated wastes at the source.

Many of the substances which cause treatment problems are also a hazard to the sewer system and should not be discharged into that system to begin with. One case where joint treatment has disadvantages is in chlorination. Chlorination is used to kill bacteria from excrement. It is usually needed for domestic wastes only. If joint treatment is practiced it will be necessary to chlorinate a much larger volume of liquid.

The most important case in which joint treatment may be uneconomical is when biological treatment is required for the organic domestic wastes and the inorganic industrial wastes would only increase the volumes to be handled by the secondary treatment unit. Separate systems may then be advisable. For instance, many steel mill wastes are entirely inorganic and probably should only be discharged after sedimentation. However even in this case, if the municipal wastes require only primary treatment, the economies of scale argument would suggest joint treatment.

Significant problems may be imposed on a single system fluctuating industrial loads as well as domestic waste. In most cases, this is not an argument against joint treatment as the industrial treatment plant would still have to cope with the fluctuations. Indeed, in many cases fluctuations from several different industries and municipalities will tend to balance one another resulting in lower variation in plant loads. Also, excess capacity resulting from a decrease in an industrial load

for a given period of time can be used to give a higher degree of treatment to other wastes during the remainder of the period. Consider a cannery that contributes half of the wastes to be treated during a few Fall months. Thus, during the critical summer period, the capacity not used for the cannery wastes could be used to substantially improve the level of treatment of the municipal wastes.¹⁹

¹ Most of the information used in this section comes from the ten industrial waste profiles which have been prepared for the Federal Water Pollution Control Administration. These profiles are scheduled to appear as Volume III of The Cost of Clean Water produced by the Federal Water Pollution Control Administration. Because this volume is as yet unavailable information from these profiles is cited simply by the name of the study from which they are taken. Detailed references to the preliminary study report volumes are available on request. Thus the information cited in the text comes from "Meatpacking Industrial Waste Profile," Cost of Clean Water, Vol. III.

² Meatpacking Industry Waste Profile, op. cit.

³ F.W.P.C.A. Pulp and Paper Industrial Waste Profile, Cost of Clean Water, Vol. III.

⁴ The Leather Industry Industrial Waste Profile, Cost of Clean Water, Vol. III, F.W.P.C.A.

⁵ George O. G. Lof and Allen V. Kneese, Water Utilization in the Beet Sugar Industry, Resources for the Future, Inc., 1967. (mimeo)

⁶ Dairy Industry Industrial Waste Profile, Cost of Clean Water, Vol. III.

⁷ Ibid.

⁸ Meatpacking Industrial Waste Profile, op. cit.

⁹ W. Wesley Edenfelder, Effluent Quality and Treatment Economics for Industrial Wastewaters, Federal Water Pollution Control Administration, October, 1967.

¹⁰ Note the reduction in revenues collected in recent years:

1954	\$715,238
1957	487,427
1960	579,574
1963	540,000
1966	495,000

See C. E. Tisher, "Cincinnati Industry Reduces Sewer Surcharges," Sewage and Industrial Wastes, Vol. 28, No. 9.

¹¹ Frankel, Economic Evaluation of Water Quality, Sanitary Engineering Research Laboratory, University of California, Berkeley, SERL Report No. 65-3, January, 1965.

¹² The data below are from Modern Sewage Treatment Plants, How Much Do They Cost? Public Health Service Publication No. 1229, U.S. Department of Health, Education and Welfare, 1964. They represent the values of the statistically fitted trend lines for various size plants.

Dollar Capital Costs per Capita

Processes	Population			
	100	1,000	10,000	100,000
Imhoff Tanks	\$146.80	\$45.54	\$14.13	
Primary Treatment — separate sludge digestion	114.96	55.93	27.21	\$13.24
Stabilization Ponds (without land)	36.31	16.10	7.14	3.17
Trickling Filter — separate Sludge Digestion	161.91	74.57	34.34	15.81
Activated Sludge	124.98	65.85	34.70	18.29

¹³ The data below are from P. P. Rowen, K. L. Jenkins, and D. H. Howells, "Estimating Sewage Treatment Plant Operation and Maintenance Costs," Journal of the Water Pollution Control Federation, Jan., 1961, p. 111-121. These values are from the statistical trend lines fitted to their data.

Dollars of Annual Operating Costs per Capita

Processes	Population				
	100	1,000	10,000	100,000	1,000,000
Primary Treatment		\$2.67	\$1.41	\$0.91	\$0.67
Activated Sludge	\$9.20	3.51	1.88	1.21	0.88
Standard Rate Trickling Filter		3.52	1.31	0.75	
High Rate Trickling		4.57	1.36	0.73	

¹⁴ See Fair and Geyer, op. cit., p. 525.

¹⁵ Fair and Geyer, op. cit. p. 405.

¹⁶ Frankel, Economic Evaluation for Water Quality, op. cit. p. 6.

¹⁷ Meatpacking Industrial Waste Profile, op. cit.

¹⁸ Paper Mill Industrial Waste Profile, Cost of Clean Water, Vol. III, op. cit.

¹⁹ For instance, by increasing the percentage of removal, the overflow rate in the sedimentation units might be halved, the recirculation rate in a trickling filter plant increased, or the holding time in an activated sludge plant or oxidation pond doubled.



**the case for
regional or
river basin
water quality
authorities**

The time has come to present the case for the creation of regional water quality agencies as the best method for dealing with pollution control problems. It should be emphasized in advance that such agencies would have significant value as an incentive to industry to cooperate with pollution control efforts. They would relieve industry of the need to make direct capital expenditures for treatment facilities, substituting instead equitable service charges for the costs of treating industrial wastes. This aspect of basin authorities would be especially helpful to firms that might be classed as hardship cases. In addition, because they can take advantage of significant potential economies, regional or basin authorities would offer most industrial firms the advantage of lower costs for its pollution abatement than it would have had to bear, had it been forced to treat its wastes by itself. Further, by shifting the initiative to government agencies, and incentives to delay felt by industrial firms would no longer hinder to the nation's rapid achievement of its water quality goals.

The costs of sewage treatment vary widely among plants depending on factors such as the quantity of waste, the availability of land, and the chemical nature of waste. For example, it is shown in the section on Economies of Scale that per unit costs varied widely with the scale of plant, and in the section on Land Intensive Technologies it became clear that whether or not a plant has access to cheap land is a major influence on the costs of waste treatment. In addition, there are a host of specific factors which affect treatment costs. For instance, will construction involve excavation of rock? Is space physically available? When all these factors are put together, it appears that there is a very wide variability in the costs of preventing a unit of pollutant from reaching a river.¹

This wide variability is illustrated by a study that has been made of the costs and waste loads produced by plants and municipalities along the major New England rivers.² The data in this study show very clearly the wide variation in per unit costs of abatement. They also show that a large proportion of the total pollution load is industrial and that frequently, due to economies of scale, the cheapest pollution to remove is industrial. The information in the report may even understate the true variation in treatment costs, such as nature of the site, probably were not taken into account in the rough cost estimates. However, this impression of wide variability in treatment costs is supported by the existing statistical studies.³

One of the basic objectives of pollution control is to maintain the dissolved oxygen level in the stream. The variability in costs in achieving any increase in stream oxygen is even greater than the variability in the cost of removing a given amount of pollutant, since the effects of any amount of pollutant on the dissolved oxygen in a stream vary considerably depending on when and where the waste is dumped. If the waste is dumped where the assimilative capacity of the stream is adequate, the gains from secondary treatment may be minimal since the damage done to the stream by the partially treated wastes is very small. Further downstream, where the pollutant load already well exceeds the assimilative capacity of the stream, every pound of BOD added to the stream will reduce the dissolved oxygen level even further below the levels desired for fish life.

In light of this wide variation, any rule that requires all plants to cut back their pollution load by a specified percentage, or to provide a specified level of treatment, will be very inefficient. Under this type of system, which is more or less like the current one, some plants will be asked to spend relatively large sums for small or even negligible increases in the usefulness of the stream, while others will not be asked to treat to the economically efficient degree. This problem is inherent in the use of regulation to improve stream quality. It is administratively impossible to examine each plant and to issue orders specifying exactly what each plant must do. Even if it were administratively possible to examine each plant individually, taking into account the nature of its wastes, its location along the stream and the cost of treating its wastes, it would be legally difficult to issue different orders to each plant. A state agency could not require one firm to spend \$100,000 for an oxidation pond and allow

difficulties with the current approach to pollution abatement

the plant just upstream to do nothing because the adjacent landowner would not sell the required land at a reasonable price. In addition, although economically efficient, such actions would certainly not be equitable.

Yet it seems clearly desirable to attempt to meet stream standards in the cheapest way possible. This requires that the level of treatment required from different plants will vary widely. There have been only two studies of specific river basins which attempted to compare the least cost solution for attaining a given level of water quality with the cost of achieving the same goal by requiring uniform treatment. In a study of the Delaware Estuary, using cost data supplied by the municipalities and industries involved, the cost of meeting stream standards by four different methods was computed. One of these required that all polluters cut back on wastes discharged by the same percentage, which roughly corresponds to the result of current enforcement policy. Also considered were schemes that required all industries to perform one level of treatment and all municipalities to perform another, and schemes that divided the river into several reaches, requiring that all polluters within a particular reach do the same level of treatment. For all cases except one, the least cost solution was substantially cheaper than the uniform cutback or any of the other alternatives.⁴

A similar study has been made for the Willamette River in Oregon.⁵ The author also found that uniform treatment was not the minimum cost method of meeting the water quality standards. The minimum cost solution in this case involved a high degree of treatment from the big paper companies which were responsible for the bulk of the pollution.⁶ A mathematical study using data based on the Merrimack River, Massachusetts⁷ gave similar results.

Thus, studies that have been made so far show that the low costs solution is significantly cheaper than requiring the same treatment of everyone. This means that it is impossible to achieve the low cost abatement by enforcement alone.

regional or river basin authorities — the basic idea

Given the limitations of the current approach, it appears that major changes are desirable in the institutional structure for water quality management in the United States. The desirable structure would be regional or basin-wide water quality management authorities.

Such authorities would be government agencies either within a state or between states (some of the alternatives possible forms are discussed below) that would be responsible for integrated water quality planning and treatment plant operation in their area. Many possible arrangements and institutional forms might be utilized. It is likely that the optimal organization would differ among areas depending on the existing political structure, the current placement of the responsibility for waste treatment, and the physical situation and hydrology in the region. The essential idea, however, is that a single agency would own and operate all of the treatment plants in a region both for industrial and municipal wastes. It would construct new plants in the optimum locations to handle increasing waste loads constructing plants in such a way as to take advantage of the economies of scale in treatment technology. The agency might frequently treat industrial and municipal wastes jointly in the same plant. The authority would be responsible for maintaining water quality in the river, would cooperate in the formulation of policies for reservoir storage and release to provide low flow augmentation, and would itself operate in-stream aeration devices where that technique was a feasible alternative for enhancing stream quality. The authority would be supported by service charges collected both from the municipalities and from industry — leaving individual political jurisdictions free to finance their share of collection and treatment costs as they wished. Some thoughts on the possible details of such charge structures are given below.

Perhaps as a transitional phase, the river basin authority would exercise control over the operation of existing treatment plants without complete ownership. Various

forms of leasing arrangements and operating contracts will have to be explored in this connection. There are some difficulties with such intermediate structures however because operating decisions usually imply changing expenditure levels and it is desirable that such decisions be made by those with ultimate budgetary responsibility.

This organizational form is one which in various guises has had wide usage both elsewhere in the world and in this country. Both in Germany and in England there are agencies for various river basins which possess many of the same responsibilities as the kinds of agencies discussed here. In addition, in this country, the experience of metropolitan area sewage agencies in Boston, Chicago, Seattle, and Washington, D.C. provides some relevant guideposts, as does the experience of various inter-state river basin agencies like the Delaware River Basin Commission and the Ohio River Sanitation Commission. Clearly some real effort needs to be made to develop and clarify the optimal form of such an agency in each situation. However, the basic idea seems so attractive that pragmatic and vigorous efforts directed at establishing such agencies should be a top priority item in the nation's pollution control program.

Compared to the current procedure discussed above, the basic and overwhelming advantage of a river basin or regional treatment authority is that it would be able to examine the river hydrology and the costs of treating wastes from different plants in order to design the minimum cost method of meeting river quality standards. Consider the small plant in a congested area. The costs of treating the wastes of this plant may be several times the per unit cost of treating the wastes from another plant elsewhere on the river. The treatment authority would be free, after considering the economics of the situation, to decide to perform only a low degree of treatment on the wastes from that plant. The treatment authority could also decide to build a treatment plant providing a very high degree of treatment for the wastes of a plant which, because of its location and the nature of wastes, could be treated very cheaply. Under the proposed schemes, these two plants would be treated equitably because they would be charged the same amount for treatment of identical wastes. Thus, the service charges they paid would be calculated from a single schedule.

Some of the advantages of such an authority can be clarified by considering a hypothetical example from the canning industry. The costs involved are within the range given by the Industrial Waste Profile on canning.⁸

Suppose along a given river there are two canning plants, one large plant with a capacity of 30 thousand cases per day and one small one with a capacity of 2 thousand cases per day. Under current enforcement procedures both plants would have to remove the same percentage of their waste load. If the large plant had inexpensive land available for constructing a treatment lagoon, it could achieve the treatment required by the standard for say \$2,000 per year in capital and operating costs. If the small plant did not have such land available, it might have to use an activated sludge process, with annual costs for this size plant as high as \$6,000 per year. Thus the small plant, which produced much less waste, would actually be spending more in total for waste removal than the large plant. In the above example in fact the small plant was spending \$3.00 each year for each case of daily capacity, while the large plant was only expending \$.07 annually for each case of daily capacity. Such a result is both inequitable and highly inefficient since money is being spent at the small plant to remove comparatively little waste in contrast with what is being done at the large plant.

On the other hand, a regional authority could decide to undertake only fine screening and sedimentation at the small plant and use spray irrigation at the large plant for virtually 100% waste removal at the latter source. In contrast to the situation which would prevail under regulation, this treatment pattern undertaken by the basin authority would produce better stream quality at lower cost. Yet it would not be possible to attain these same results under regulation because under the basin authority plan most of the waste removal along the river would be done at the large cannery. Under the basin authority approach, however, both canneries would pay for waste treatment under the same schedule of fees leaving the authority free to work out the most efficient method for meeting stream standards.

the structure and organization of regional or river basin water quality authorities geographic scope

What is the optimum scope for a water quality management authority? It would appear that the bulk of the benefits from such an authority could be obtained if it included all the area of a single river basin within a single state. Much can be accomplished with authorities of limited geographical scope by concentrating treatment of those waste sources that can be treated at reasonable cost and by exploiting the benefits of adjusting waste discharges to stream flow. The great advantage of limiting authorities to a single state is that the time consuming process of negotiating interstate compacts can be avoided. Except where such negotiations show promise of taking place rapidly, it would seem wise for each state to concentrate on setting up authorities for its intrastate rivers and for those portions of interstate rivers that flow through its territory.

In most cases, depending upon the size of the river basin this will result in several successive authorities along interstate rivers. However, this situation should not be that much less efficient than having a single agency with authority over the whole river especially for smaller river basins. The resulting pattern can be clarified by an example. Although it would be desirable to have the Merrimack River managed by a single authority in Massachusetts, very little would be lost by having the northern portion managed by an authority in New Hampshire. It is true that some efficiency would be lost compared to a single authority if, for example, the least expensive way of improving water quality in the Massachusetts part of the river was to increase the treatment of wastes generated in New Hampshire. Also, disagreement might arise between the two authorities over the desired pattern of seasonal releases. However, such problems would still be much simpler to solve with one authority responsible for water quality in each state's section of the river than with a great many treatment agencies. In any case, Massachusetts would not be made worse off by a New Hampshire treatment authority on the Merrimack because the authority would be responsible for meeting water quality standards, not setting them, and Massachusetts would get the same quality of water with or without the New Hampshire authority. It is even possible that such significant savings in the cost of meeting the existing standards would occur in New Hampshire that the state would decide to raise its stream standards and Massachusetts would receive cleaner water than it required.

Similarly, a great deal could be accomplished by having a few state authorities responsible for water quality along each of the major tributaries of a large river like the Ohio. Additional authority for the main stem of the Ohio, which would obviously require an interstate compact, would attempt to meet the Ohio River standards by appropriate treatment and stream management. The main stem authority would take as given the quality of water entering from the tributaries that resulted from each state authority meeting the quality standards along its section of its tributary in an efficient manner.

There are both advantages and disadvantages of having a single statewide agency instead of separate authorities for each basin. A Commission has recommended a state-wide authority for Maryland for essentially the same reason that basin-wide authorities are recommended here.⁹ There is something to be said in favor of a state wide authority because of the economies of scale in providing services such as training and laboratory facilities. Cases occasionally occur in which the best solution for the pollution problems along one river is to pump wastes to another river with higher assimilative capacity or into the ocean. This approach has been proposed as a possible solution for quality problems of the Delaware and Potomac estuaries. Authorities limited to a single basin may run into problems in accomplishing such schemes. However, due to the high cost of pumping sewage from one basin to another, cases in which this is the least cost solution are rare.

A disadvantage of statewide authorities is that there would be a natural tendency for the same level of charges to prevail over the whole state. This is clearly undesirable if a higher level of treatment is required in one basin than in another. In addition to providing appropriate incentives to process changes, such a charge difference between basins will discourage industries with severe pollution problems from locating where their pollution is very expensive to treat.

A useful compromise to consider would be a state-wide agency that provided coordination and had some control over separate basin units within the state.

In order to maintain water quality efficiently, it will be necessary for the proposed regional authorities to take over and operate existing local government waste treatment facilities, such as those owned by municipalities or special sewage districts. The regional agencies would also take up the burden of the outstanding debt used to finance the construction of these facilities.

relationship to existing sewage authorities

The new authority would be responsible to the municipalities within its jurisdiction and to the appropriate state agency for providing sufficient treatment capacity to handle the growth of domestic wastes from population expansion. Municipalities and other organs of local government would pay the agency for waste treatment on the basis of the costs to the agency of providing such services. The basic schedule would be similar to the industrial charge pattern discussed below. However, if the regional agency received federal grants for constructing treatment capacity for domestic wastes (as is advocated later in this report), then these savings would be passed on as charge reductions to the local bodies whose waste is receiving the federal subsidy. Local governments could raise the funds to pay the waste treatment fee from their own resources in any manner they chose, thus not disturbing present arrangements at the local level for financing waste treatment.

Because of the economies of scale and other advantages of central authorities, local governments should significantly benefit from the proposed plan in terms of lower real costs of waste treatment. Another benefit would be that limited local bond capacity would no longer have to be used to finance sewage treatment plants. The trend toward cooperation among municipalities for waste treatment, which is increasing as states begin to take seriously the attainment of water quality standards, reflects their appreciation of the same basic facts that make systematic regional authorities desirable.¹⁰ In addition, regional authorities would relieve municipalities of the difficulties of securing qualified operating personnel and of the problems of negotiating with industrial firms for waste treatment in the municipal system. Thus municipalities should have few objections to the proposed plan for water quality authorities on either a river basin or state-wide basis. Rather, they should welcome them as an effective and economical answer to the problems of treating domestic as well as industrial wastes.

The proposed authorities would be responsible for all measures undertaken to offset the effects of pollution. The activities of the authority would be financed by service charges levied on the municipalities and industries of the basin whose wastes were being treated. The system of charges would be designed to encourage industry to reduce waste loads. As firms tried to reduce their treatment costs, they would reduce the pollutants that reached treatment plants and hence that reached the river.

service charge structure

The exact structure of service charges would be created by each authority and therefore would vary. The desirable approach is a structure of charges that responds to a variety of characteristics in the waste load — each aspect of the structure reflecting the average cost of the treatment facilities in the system whose size depends upon the relevant waste characteristic.¹¹ To be more specific, the cost of certain items such as interceptors, pumps, and settling basins would be found to vary with the volume of waste the authority plans to handle to give a charge of so much per cubic foot of sewage. The purpose of this element in the charge system is to encourage plants to reduce the volume of sewage they discharge, which would in turn reduce the costs of treatment since these costs are related to volume treated.¹²

An estimate would be made of the treatment cost related to suspended solids in the waste (primarily the costs of sludge digestion) and a charge per unit of suspended solids would be set in the same manner as the volume charge. The charge system would also include a charge per unit of BOD designed to cover the costs of secondary treatment not allocated to the volume of sewage. Similarly, where the effluent is chlorinated, a charge based on chlorine demand should be included. Additional special charges would probably have to be levied to cover the extra costs associated with particular types of effluents, such as the costs of neutralizing acid or basic wastes. The charges preserve the incentive for process change, for which there appears to be considerable scope.

Even though the firm no longer operates the treatment plant directly, it seems possible to incorporate into the charge structure and administrative rules adequate incentives to the firm to avoid waste discharges damaging to the treatment plant or difficult for the system to handle. Some types of wastes, like acids, could be barred from the system entirely unless the firm provided pre-treatment. This is frequently done in municipal systems today. Special penalties could also be instituted for especially erratic discharge patterns, or for putting sudden unusually large loads on the system. The benefits of such charges would of course have to be balanced against their administrative feasibility.

Once the assimilative capacity of a stream is fully used, every additional unit of pollutant produced along the stream has to be offset by an increase in the level of treatment somewhere along the river. Furthermore, the cost of removing an additional unit of pollutant generally rises as the degree of treatment increases. This implies that the marginal cost per unit of pollutant removed is above the average cost. Therefore, charges based upon the average cost of treatment will be lower than is optimal. If charges are set equal to average costs, firms will only engage in process changes as long as the cost of such changes is less than the costs of the service charges they avoid by doing so. Efficient firms will engage in process change only until the cost of removing the marginal unit of pollutant by process change is equal to the service charge. But the service charge is equal to the average cost of treatment and not to the higher marginal cost of treatment. The point is that because service charges would be lower than the marginal costs of treatment, process change will be carried out less than would be optimal. It should be noted that economies of scale in sewage treatment costs are such that charges based on the average costs of handling volume will be higher than marginal costs. Subject to the constraint that average charges must equal average costs (the political opposition to making a profit on sewage treatment make this constraint necessary) an improvement in efficiency can be obtained by increasing the allocation of joint cost to the removal of suspended solids and BOD and reducing the allocation to volume. This argument should be kept in mind when setting up the original charge structure.

Service charges to finance a water quality management authority have many of the benefits usually claimed for effluent charges. (See the section on Effluent Charges below.) Service charges differ from the theoretically ideal system of effluent charges in that they are likely to be lower, will probably be constant for the entire authority instead of varying along the river and would probably not vary with the time of year, although the last two complications could be introduced into any system of service charges if the benefits seemed worth the added administrative complexity since the management authority is free to design for a higher degree of treatment in some river reaches than in others, and to vary the level of treatment and timing of discharges with the time of year, most of the advantages of a sophisticated effluent charge system would be obtained by a regional authority without having the same complicated charging system.

It is a mistake to assume that a system of effluent charges will have the superior virtue of leading to the equality of marginal costs of treatment at different plants. With effluent charges, the level of treatment done at different plants, and hence the marginal costs of such treatment, will differ depending upon such variables as the access to capital markets and the alternative investment opportunities of whoever is doing the treatment. In particular, therefore, the response of municipalities and industry will differ widely if they both confront the same schedule of effluent charges. The typical municipality, with access to low cost, tax exempt borrowing, and federal subsidies, and subject to public pressure for clean water, will perform a much higher degree of treatment than the typical firm, which will not have these advantages. The water quality management authority, on the other hand, will be able to decide directly where it is cheapest to do treatment on the basis of the explicit costs of treating each plant's wastes rather than having the decision dictated by the somewhat uncontrolled actions of the capital market and the results of the grant program.

The authorities would make long term contracts with local industries and municipalities to protect them from losses if a plant closed down. It should be possible to write contracts in such a way that incentives for process change are maintained while giving a guarantee against the authority being left with a treatment plant with

no wastes to treat. With such contracts the authorities could borrow at low, tax exempt rates in the capital market. The advantages of cheap financing and no property taxes should help make the scheme appealing to industry.

Of course, the costs of collection and administration of an industrial charge program for a river basin authority may be quite heavy — especially in urban areas. This is illustrated by the experience of the municipal sewage system in Cincinnati when in 1966 "Surcharge Collection and Sampling and Gauging" cost \$175,250.17, which was over a third of the total service charges collected from industrial waste sources.¹³ The high cost of sampling in this instance results from Cincinnati's practice of taking samples every few minutes over a whole week once each year for every industrial plant connected to the system.¹⁴ The city estimates that one week of around the clock sampling for each firm costs about \$900. The resources required for effective sampling are high enough so that inadequate sampling may interfere with adequate administration of a treatment system if insufficient effort is devoted to this part of the program. In New York City, due to inadequate personnel, five years after the establishment of the industrial charges system, it has still not been possible to sample all industrial firms even once.

There are several ways in which regional water quality authorities might reduce the sampling and other administrative costs of a sophisticated industrial service charge system. First, there has been very little research and development effort devoted to automatic samplers, sampling techniques, and inexpensive continuous monitors for waste characteristics like suspended solids or BOD. It is significant that both New York and Cincinnati have found it necessary to design some of their own equipment because appropriate devices were not available. A small amount of research money spent on the development of low cost techniques for determining pollutant loadings would yield very high returns. Research on this problem should be given high priority in the allocation of research grants by the F.W.P.C.A.

Second, an authority need not fully sample every plant. It costs about the same amount to sample a small plant as a large one. The most effective way to limit the cost of sampling is to only sample the large plants, whose effluent make the major contribution to the costs of treatment plants. This policy is justifiable on efficiency grounds. Whenever the potential difference between the costs of process change and the costs of treating the waste that would be eliminated by process change are less than the costs of the sampling needed to bring about the process change, it is ultimately less expensive not to sample, not to have process change, and to do the extra treatment required instead. Large firms are the ones which have the most potential cost savings from process change. Detailed examination of past experience with service charge structures ought to make it possible for the policy maker to decide on the minimum appropriate size level for detailed sampling.

It is both inequitable and inefficient, however, not to charge the small plant anything for sewage treatment if this can be done at reasonable administrative cost. Thus, for small plants, it may be possible to base charges on industry averages for BOD or suspended solids per unit of waste volume and to base volume charges on existing water meters. One could even consider only charging small plants on their waste volume, which would be a slight implicit subsidy to the owners of such plants. This would be compatible with the demonstrated desire of society to aid small business.

As a treatment plant is usually designed to remove a specified percentage of the pollutants, the larger the load of pollutants going into the plant, the larger the load coming out of it. Thus, downstream users have a strong interest in the method chosen by upstream municipalities for financing waste treatment. The level of service charges for treating industrial wastes has a large effect in reducing the amount of pollutants reaching the treatment plant and hence the stream. This is one more reason for regional water quality authorities, which can take into account downstream interests in setting appropriate service charges and in constructing treatment facilities.

There is some real question as to how to construct service charges for waste sources other than either simple households or industrial plants, such as hotels, restaurants, boarding houses, stores, theaters, exhibition halls, etc. Currently, many of these

businesses pay for sewage treatment by means of municipal systems on the same basis as do households in the same municipality, that is, either through property taxes or via charges included in water rates. From an efficiency point of view, in those cases service charges are unlikely to have any effect on the waste load produced so that there is no special reason to bring them within the purview of the industrial charge structure on this account. However, on equity grounds, large commercial establishments like major hotels ought perhaps to be included. It does not seem either feasible or sensible, however, to extend such charges to small boarding houses or restaurants.

basin authorities and federal grants

If service charges are to be used to induce process changes and if, as argued above, the level of charges based on average costs will be below the ideal level, then it will be undesirable to give any subsidies to municipal or regional agencies that would result in an even lower level of charges to industries. Thus, regional authorities should not receive any subsidies from the Federal government towards the cost of industrial waste treatment, because any such subsidies will serve to lower service charges, decreasing the motivation to process changes and increasing the pollution load reaching the rivers. Grants should be limited to the share of costs which go for treating domestic wastes.

The exact line between the industrial and the domestic sector should be drawn in the manner discussed previously when the current municipal construction grant program was considered. The appropriate procedure would be to include major service businesses like large hotels and laundries in the industrial sector and to consider the effluent from boarding houses and laundromats and similar "plants" as part of the domestic waste load.

Since federal funds for treatment plant construction are limited, some priority should be given to basin authorities when such funds are given out. This will give municipalities a real incentive to cooperate in setting up such authorities. A municipality that is part of such an authority would not have to construct its own treatment capacity. This will allow plant construction to go forward without the retarding effects of existing limits on local bonded indebtedness in many states. However, in order to preserve the option to construct efficient plants in the future, policy makers should not give priority to municipal plants that are planned without regard to the basin-wide situation. In short, because improvements in water quality can be obtained at lower cost with construction of many treatment plants, the federal government will get the most improvement in water quality by concentrating its limited funds on basin authorities.

There will be little problem in encouraging the smaller industries to have their wastes treated by regional authorities because aggregate service charges will be lower than the cost of building their own treatment plants. The possibility remains, however, that a large plant might find it cheaper to do its own treating than to join the authority.

This raises the problem of how to encourage industries to go along with the water quality treatment authorities, even if it does not appear in their interest to do so. One solution is to require all industries to have their wastes treated by the appropriate authority. This procedure has been advocated for the State of Maryland.¹⁵ Some have suggested that "establishing and enforcing unreasonable discharge requirements could pressure all dischargers into the association."¹⁶ Another possibility is to negotiate charges based on the costs of the plant for doing its own treatment, if the plant can show that it can meet the effluent standards more cheaply on its own. The efficiency loss from allowing a few industries to treat their own wastes is small if they meet stream standards by performing a high level of treatment, although there may still be some efficiency loss in not having these low cost industries in the system. However, it might have been economical, from a basin-wide viewpoint, to have these plants with low treatment costs perform an even higher level of waste removal than would have been required by stream standards. If the least cost system of treatment involves an oxidation pond, there are advantages in being able to co-ordinate its releases with stream flow and with waste releases from other sources along the river. Yet, in general, while 100% participation is desirable, it is not necessary for the system to function.

What incentive will industry have for co-operating with a basin-wide authority? Basically, the incentive is the opportunity to take advantage of the same economies that make it desirable to have basin authorities in the first place. Most industries will find that the charges levied on them are less than the cost of performing a high level of treatment on their own. In addition, they will participate in the economies of low cost financing and will be relieved of the need to either raise additional capital or to administer a pollution control program.

In order to allow basin authorities to utilize stream hydrology, the federal government must not insist on abatement standards in terms of uniform year-round levels of waste treatment or rates of waste removal. Such standards would interfere with the ability of the basin authorities to find the low cost combination of storage, treatment, and other methods for attaining stream quality. Except where a river crosses a state line and there is no interstate organization responsible for maintaining the usefulness of the water, standards should be expressed in terms of dissolved oxygen levels rather than in terms of BOD. Regulation of the BOD content of water where it passes from one authority to another is needed, however, to keep the downstream users from being presented with an unsolvable problem.

No change is proposed in the mechanism by which water quality standards are created. The proposed basin authorities are to be responsible for finding and implementing the low cost method of meeting the standards, not for setting them. They should play an advisory role in setting standards, however, as they could make a significant contribution to the rationality of the process. When a change in river standards is proposed, it will be possible for the responsible authorities to estimate the costs of meeting the new standards. With reliable data on abatement costs available, an informed public should be better able to decide what quality of water it is willing to pay for. The current standards were set without the benefit of such sound estimates of the costs of compliance. As a result, they may have been set either too high or too low given the actual costs and benefits that will ultimately result. An authority which could provide cost estimates in advance could help avoid such mistakes in the future.

One solution to the problem of new plants is to charge them the increase in system costs due to their waste loads. This increase in system costs is composed of two elements. One is the cost of the treatment provided at the new plant and the other is the cost of additional treatment at existing plants needed to prevent the total BOD load in the stream from increasing. Charging new firms the full additional costs they impose will influence their locational decisions and encourage them to locate where land is available for inexpensive abatement methods. There is a second advantage to charging the new firms for the full additional costs they impose. The possibility of substituting process change for treatment is likely to be greater for new plants than for old plants. If charged the correct marginal cost, new plants will be designed to minimize their waste production.

A major objection to this solution is that it seems inequitable that two firms, one old and one new, producing identical quantities of waste, should be charged different amounts. This problem might be handled by charging everyone the full marginal cost and using the excess income for government activities other than waste treatment. To use these funds for subsidizing additional treatment would lead to inefficient treatment capacity.

If new firms are charged more than existing firms the low charge dumping rights of the old firms would have to be made transferable. Without transferability, firms will maintain uneconomical, obsolete, plants beyond their normal lifetime because the operation of these original plants carries with it a lower level of treatment charges than would the replacement capacity. However, such rights seem to be politically unrealistic and to have adverse income distribution effects.

None of the three alternatives considered so far for dealing with new firms appears to be entirely satisfactory. Charging new firms only the average cost of treatment removes waste treatment costs as a factor in locational decisions. Charging them the

relationship to water quality standards

charges for new plants

marginal cost of treatment is inequitable and requires the creation of transferable rights to low service charges for efficient operation, although it is unlikely that the latter would be created. Since marginal costs are above average costs, charging all firms the marginal costs of treating the wastes of new firms would create a surplus in the authority's accounts. This surplus would not be undesirable provided it was not used for waste abatement. Yet it is hard to see this as politically feasible.

Earlier, an average cost charge scheme was advocated. Perhaps the best way to reconcile that recommendation with the requirements of efficiently handling the new firm is to suggest that new firms be assessed a substantial connection charge that will reflect differences in the long term costs to the authority of treating wastes at different locations. Perhaps this charge could even be assessed over the first few years the new plant was connected to the system. This solution is hardly perfect, but should preserve many of the incentives to economical plant locations without the complications of other alternatives. It would also have the advantage of allowing all plants to be charged on the basis of the same service charge schedule, a procedure with much lower administrative costs than the other alternatives. For example, this system could be used to encourage firms to purchase land at low cost for treatment facilities when they first assembled the basic site for plant construction. Firms could then sell or lease such land to the authority in return for an appropriate reduction in connection charges.

use of in-stream aeration

So far the discussion in this report has been focused on various treatment techniques as a method of attaining water quality. However, there are other methods for maintaining the dissolved oxygen level and otherwise dealing with pollution problems that can be applied directly to the stream. One of the great advantages of a central authority is its potential ability to integrate these methods into an overall program of water quality control.

One such treatment alternative is in-stream aeration. It is possible to raise the assimilative capacity of a stream by adding oxygen directly to the water. This is usually done by using compressed air to aerate bubbles under water or by using mechanical devices to agitate the water.

In many circumstances, this could be the low cost solution for a dissolved oxygen problem, but it is a solution which probably could not be implemented without a basin authority. One study of the Potomac River Estuary showed aeration —using mechanical means to be a very efficient tool for solving the estuary's dissolved oxygen problems, assuming that some secondary treatment had already been undertaken.¹⁷

Another study involving re-aeration was done on the Willamette Basin in Oregon.¹⁸ A major problem in the basin is the low level of dissolved oxygen in Portland Harbor. Low oxygen levels prevent up-stream migration of salmon and other fish. Dealing with the problem by means of low flow augmentation required additional reservoir capacity costing \$20 million and treatment facilities costing almost \$24 million. However, by closing the hydroelectric plant at Willamette Falls above the harbor during the critical season, the oxygen concentration could have been maintained in the harbor as a result of the aeration of the water going over the falls. The cost to the pulp and paper mills of purchasing more expensive power to allow this alternative to be used would have been less than \$100 thousand. However, the solution was not chosen apparently because of the lack of an adequate institutional framework to compensate the companies. This is the kind of difficulty a basin authority could help overcome.

involvement in low-flow augmentation

Another alternative to waste treatment, and especially to waste storage, is low flow augmentation. This method consists of programming special water releases from dams during the summer slack periods to raise the flow in the river. As was pointed out previously (see the section on Stream Hydrology), many of the adverse effects of pollutants depend upon their concentration. Raising the amount of water available to dilute such wastes during critical periods is one way of lowering concentrations and increasing water quality.

Once it is accepted that basin authorities are needed for an efficient organization of pollution abatement, there remains the problem of who is to take the lead in organizing them. There are four logical possibilities: cities, the states, industry, or the Federal government acting through the Federal Water Pollution Control Administration. In practice the cooperation of all four is needed, although the role each can be expected to play is somewhat different.

implementing the basin authority plan

sources of leadership

In organizing the envisaged authorities, it would appear that a key role will have to be played by the states in most cases. Such authorities can only begin to function through enabling legislation from state legislatures. Such action will often be needed even to allow cooperating cities to participate in joint venture schemes. The states will either have to pass a general enabling act with provisions for an administrative procedure to pass on the establishment of each authority, or a series of special acts ratifying the provisions negotiated for each particular basin by the participating jurisdictions. If a state decides to set up a single statewide authority, this too will require legislative action.

In any case, the organizational form would have to be set by the enabling act, which would also impart to the agencies necessary powers such as the power to construct, buy, or lease facilities, the power to borrow money, to sue and be sued, perhaps eminent domain and so on. The major advantage of a general enabling act is that it would simplify the subsequent process of creating individual agencies. Problems such as the distribution of voting power, the area to be included, the selection of a manager, as well as specific engineering problems such as where to locate outfalls, can easily impede negotiations. If there is an established policy on many of these matters and a specified procedure for reaching agreement on the others, negotiations will proceed much more smoothly, and the chance of failure to reach agreement will be much reduced.

Without some efforts from the states, basin authorities may fail to be established, not because of any opposition but because the required leadership never emerges. In many cases the gains to any one city or industry may seem too small for it to justify the effort involved in trying to help the region as a whole achieve a more efficient solution to the pollution problem. The least effort path an individual city or industry could take (rather than the least cost solution) might well be to design a treatment plant to do the minimum required level of treatment. This method avoids the perhaps difficult task of creating a basin authority. If such an authority is proposed, its chances of success are reduced if there is doubt as to whether the legislature will pass the required legislation. Of course in some states the legislature may wish to take stronger action than merely passing an enabling act. An act may be passed which mandatorily establishes the authorities themselves, perhaps even requiring participation by the relevant industrial plants and cities.

What role can we expect the cities to play in this process? Where leadership comes from a city it would probably have to be from the largest one or two cities in a basin. The smaller cities can be expected to participate willingly if not to take the lead because their costs for a high level of treatment will be well above the charges likely to be levied by an authority. Small size, however, would appear to be a barrier to such towns taking a major leadership role. This possibility raises a serious problem facing the effort to establish river basin authorities. The largest gains from such a plan would be realized by the smallest potential members who because of their size have less organizational leverage than the major pollution sources. The current treatment costs of the bigger cities on the other hand may well fall below the charges an authority would be likely to levy. The major incentive for these larger cities could come from several sources: savings to the city through the authority's superior ability to utilize seasonal operation or in-stream aeration; freeing the city's bonding capacity from the burden of financing sewage treatment plant construction; knowledge that the agency would enhance water quality in the area of the city by providing adequate treatment upstream; and perhaps federal monetary incentives in the form of administrative grants or of priority to requests from basin authorities for construction grants for facilities to treat household wastes — grants which are authorized by current legislation.

Another possible reason why some cities might be reluctant to cooperate in creating a basin authority is that they would lose control of what was a local function,

and lose control of the jobs formerly provided by sewage treatment operations. Actually, of course, the removal of pollution control from any local "spoils system" is one of the advantages of establishing a basin authority. Where local appointments were merit-based to begin with, there should be no local objections on these grounds.

Since businessmen are not used to promoting new forms of political organization, industry may not take the initiative in establishing basin authorities. But the gains to industry in the reduced cost of treatment, the relief of the need to raise capital for pollution control investment, and the gains in reduced managerial effort for water pollution should lead to business cooperation in the establishment of river basin authorities.

How does the Federal government encourage the adoption of the basin authority system? One approach is to use the present program of grants for treatment plant construction but to give some type of priority to basin authorities. This would give the municipalities a strong incentive to cooperate in establishing basin authorities. Another important contribution the Federal government can make is to refrain from imposing rigid requirements on end-of-pipe treatment efficiency regardless of stream flow if the stream standards are being met. This is needed to allow the authorities to reap the advantages of doing a high level of treatment at low cost plants and a lower level elsewhere. It is also needed to permit the adjustment of releases to stream flow and time of year. Without this kind of flexibility open to the authority there is almost no reason to proceed with the plan.

In addition, Federal funds for comprehensive river basin planning should also be made available for the preliminary planning necessary to create basin authorities. Planning funds should be available to help authorities determine the best integrated approach to pollution abatement in their area. From this point on, the Federal Water Pollution Control Administration should specifically require that all federally financed comprehensive plans must include an investigation of the low cost solution to the abatement problem to provide guidance to any authorities created in the future. Such investigations should not be restricted to solutions which involve secondary treatment everywhere, and which only allow the use of low flow storage, tertiary treatment, and so on in those cases where the secondary treatment is inadequate. Instead consideration must be given to solutions which involve storage, in-stream aeration, systematic placement of outfalls, less-than-secondary treatment at some locations, and the construction of a few large treatment plants. Further, if planning studies are conducted so that their results include data about both the best solution possible without a basin authority and the solution such an authority could adopt, a comparison of the costs of the two alternatives would indicate in each case how large the gains from establishing a basin authority can be. Where the gains are large, as it appears they usually would be, the publication of the plan will serve to encourage action to create the authority.

The F.W.P.C.A. can also encourage the formation of basin authorities through their demonstration grant program. To actually have a basin authority responsible for all treatment established and operating in this country with support of demonstration grant funds would be very useful. The experience gained in establishing and operating such an authority would provide very helpful information for use in establishing future authorities. Although not every basin authority should be established with a massive dose of Federal aid, the advantages of having the first few operating suggest that this is a perfect use of the demonstration grant program.

Yet another way in which the Federal government could assist in establishing basin authorities is through public education. Many local officials may not be familiar with the advantages to be obtained through coordinated planning of a whole basin. This is especially true of officials whose primary concern is not sewage treatment but other aspects of government. The F.W.P.C.A. could be very useful in informing them of the advantages of the basin authority approach.

voting and control

In creating a river basin authority, some attention should be devoted to establishing a structure that will be responsive to the needs of the waste dischargers it serves. One method of encouraging such behavior is to have the various pollution sources

themselves participate in the administration of the authority. This is the pattern in both British and German river basin pollution control organizations. Such an organizational pattern, where some sort of managing board represents the relevant interest groups, seems most desirable as a means of preventing basin authorities from developing into independent bureaucracies unresponsive to local interests.

How will the proposed pattern be implemented? One obvious but not necessarily desirable solution is to have the votes controlling the authority proportional to the financial contributions of the members, which under most charging schemes would be proportional to waste discharged. With such an approach, however, cases would arise in which a single waste discharger is responsible for over half of the wastes discharged. Votes based strictly on wastes discharged would then give the single discharger control of the authority. Even where the largest discharger is not this large, there might be many instances where the concentration of power that would result from strictly proportional voting would be considered undesirable. Thus it might prove necessary to limit the votes of the largest discharger (city or industry) to some specified fraction of the total (such as 25%). The opposite extreme of one vote per member seems to separate control too much from financial responsibility. It might well lead to domination of the authority by small towns or firms, greatly lowering the incentive to the largest dischargers to cooperate in creating the agency. It has been argued elsewhere that the big polluters have much less to gain from the establishment of the authorities than small municipalities and industries. Thus it seems undesirable to reduce further their incentive to cooperate by refusing to give them power commensurate with their financial responsibility.

There is also the problem of whether to give governmental authorities and industries equal power within the organization. One possible position on this issue is that water quality is solely a governmental function and that industrial participation is undesirable. However the basin authorities would not be responsible for deciding on the level of water quality to be maintained, but only for finding the cheapest way of doing so. In light of this, it might be desirable to have participation by all those whose waste discharges contribute to the problem. This is especially true for rivers whose problems are predominately industrial, such as many rivers in northern New England. In addition, industry's active participation should help to reduce the possibility that jobs in basin authorities would be used as rewards for political service rather than going to technically qualified individuals. Where regional or basin-wide agencies are actually created by state governments, there still remains the problem of representation in agency decision and of determining the pattern of control. In this case it is possible for the state to appoint the governing bodies of the basin authorities, perhaps in accordance with some formula that insures participation by all of the relevant groups.

Unlike some other forms of special purpose agencies at the sub-state or inter-state level, the exact political structure of basin authorities does not seem to be crucial to their vital functioning. The agencies will exist to meet a reasonably restricted and well-defined objective: namely improving stream quality at least overall social cost. There should be no room for the kinds of empire building and self-interest that some existing special agencies have displayed in the past. The purpose of a basin authority is not to maximize its own surplus of revenues over expenses. The reason political structure is not vital is that how basin authorities choose to meet stream standards is not likely to make a major difference to any of the pollution sources involved. In this they differ from regional organizations which provide parks, roads, airports, or industrial sites. In regional organizations concerned with such matters the location of the facilities and their exact nature is very important indeed to the members. Whether a road runs through one town or another is an issue worth fighting over. And the exact nature of the political institution used to resolve conflicts between towns in such cases is important to the nature of the outcome. However, the pollution control basin authorities proposed in this report should have fewer serious conflicts of interest to reconcile. Their job is ultimately to a large extent an engineering problem. The most important conflicts will probably arise over where to place treatment and storage facilities, and over the location of outfalls, since communities may be reluctant to have such facilities located near their residential or recreational areas. The major economies in waste treatment would seem likely to be achieved under almost any form of organization for the basin authority. It is important that basin authorities be established. Their organizational structure no doubt will and should vary with the region involved.

establishing an integrated wage structure

There are likely to be problems in establishing an integrated wage structure when a variety of local municipal and industrial plants are combined into a single system. If overall wage levels are set near the level of those in the more highly paying plants, many workers would receive a pay increase when this system is established. However, this upgrading of salary levels with the establishment of the agency may often be highly desirable. As discussed elsewhere in this report, current municipal salary scales are often quite low and higher wage levels may be crucial to more adequate treatment plant operation.¹⁹ In some cases there might even be cities whose pay scales are above the levels set by the basin authority which could be a source of resistance to the scheme as a whole. A similar problem which might well be quite serious will occur when the existing treatment facilities of industrial plants are brought into the system. Workers in such plants will often have been paid at a level well above prevailing municipal pay rates. This will create real problems in bringing such existing industrial treatment plants into the overall system. It may be necessary in such cases to have a separate pay scale for these treatment plants. In other instances the solution might be for the basin authority to contract back with the industry for the operation and maintenance of the plants. Such problems will have to be worked out in detail and individually for each separate basin.

some specific advantages of regional authorities efficient plant operation

Elsewhere in this report there is a discussion of some of the severe problems that are being encountered in operating existing municipal treatment plants. One of the problems has been that pay scales for operators are inadequate and when combined with the low prestige of the job, cities have generally failed to attract good operators. Adequate training has not always been available for those that are attracted. A river basin authority would have several advantages that would allow it to mitigate these problems. The wages a basin authority could pay would not be controlled by the existing and often low civil service wage structures of the communities whose wastes are being treated. It would be possible to raise operators' wages without upsetting a long established wage relationship among municipal employees. An authority operating a number of treatment plants would be large enough to organize training schools for operators, thus helping to solve the problem of poor training.

One of the problems with current operators is that they often lack the understanding of the technology of waste treatment that is needed to meet emergencies and changing conditions. With the proposed basin authorities, the treatment plant operators would be supervised by men who knew the technology of waste treatment. Routine problems could be spotted before they became serious and expert advice on how to deal with them would be readily available. Where major problems were encountered, a basin authority would have experts available. With basin authorities, a higher degree of specialization should be possible than most municipalities can now achieve.

In the current regulatory system, the emphasis is on construction of treatment plants, not their efficient operation, especially since the regulatory agencies have only a limited staff. If a plant is designed to remove 80% of a pollutant and in operation it removes only 70%, there is little a regulatory agency can actually do about it regardless of what it may be authorized to do by law. However, if the failure to perform adequately is due to a specific plant difficulty, the municipality can be required to correct it. A plant addition to raise the percentage of pollutant removed by only a few percent would be extremely inefficient. Moreover, current regulatory authorities have no authority to insist upon an economically efficient major plant addition which would raise the level of treatment far above the minimum required. This problem would not arise in the dealings of the regulatory agencies with the basin authorities. If the required standard is not being met, it is practical and economical to insist that one of the plants in the system perform a higher level of treatment. Since it is always faced with the possible need of building new capital facilities if existing plants do not fulfill their intended role in meeting water quality standards, the basin authority can be expected to pay more attention to efficient operation than current municipalities do.

Regional water quality authorities have certain advantages for the operation of a water quality management system as well as for the original design of the system. For example, such authorities should be able to meet short term emergencies efficiently, such as an accidental spill upstream. As the spilled waste passes downstream, most other wastes could be stored to hold the total waste load to the lowest possible level. Also, short term action could be taken to increase the level of treatment of the wastes that cannot be stored. Arrangements made in advance with the agencies operating reservoirs for emergency flow releases would be put into operation and the river could be restored to its full stage to provide the maximum dilution of the wastes. A basin authority is well equipped to handle such an emergency quality problem; while such emergencies are rare, they can have serious results such as large fish kills.²⁰

Analogously, having a single operating organization improves the response to short term changes in hydrology. If stream flows are less than expected, it is possible to store more wastes and if flows are greater than anticipated, more wastes can be released. In particular, very large releases can be made during flood periods to take advantage of the high dilution such a situation offers.

Even with several distinct state authorities along a stream, many of these advantages can be obtained by adequate advanced provision for coordinating them.

Notice that the largest benefits of the proposed system accrue to the plants with high treatment costs, such as small, old plants located in congested areas and with a high pollution load per unit of product. These plants would pay charges based on the average cost of the whole system, rather than the very high costs they would otherwise have to pay for a high degree of treatment. It is exactly these plants that are most likely to be forced out of business if required to build treatment plants, which is why basin or regional authorities will do much to alleviate hardship cases. Thus, the proposed treatment authorities should be able to bring about a major improvement in stream quality with much less risk of causing any plants to close. Because the capital for treatment would be raised by the authority rather than by individual firms, the problem of the small firm unable to raise the funds needed to build a treatment plant is avoided.

Since regional authorities would be responsible for meeting the same quality standards as the states are now trying to meet, there would be no reduction in the quality of the water. Indeed, the level to which stream standards can be raised at the moment seems to be limited by the costs that can be imposed on the small firm with high treatment costs per unit of output. Thus, having a more efficient institutional device available for improving the quality of the nation's waters would permit standards to be set higher than they otherwise could be.

The point of this discussion has been that there is no simple solution to the industrial pollution problem. Each river basin is unique. Any attempt to solve the problem by requiring a particular action of everyone all the time is bound to be inefficient. A regulatory system can provide minimum standards for each plant, but it can do little else. Efficient abatement requires an intelligent program designed to facilitate the complex choices involved in balancing alternative methods for attaining water quality. This is the basic rationale for the creation of a new institutional structure, which has the ability to consider alternatives and make sensible decisions. This is why Congress should make every effort to encourage the creation of regional water quality authorities.

1. Regional or river basin water quality authorities should be established which would do all industrial and municipal waste treatment in an area in return for reasonable service charges. They should consider seasonal storage, land intensive methods, stream hydrology and all other factors and alternatives in creating the least cost program for attaining water quality.

2. Where setting up interstate agencies would result in delays in implementation, authorities should be set up for that part of each river basin which is within a given state.

management of special situations

assistance in dealing with hardship cases

conclusions and recommendations

3. State-wide agencies should also be considered, provided they could apply different charge structures in different river basins within the state.
4. Regional agencies would take over existing municipal treatment plants and be responsible for providing new capacity to handle the waste load increases from population growth.
5. Industry should be charged the average cost of waste abatement, with the charge structure reflecting waste characteristics, such as the volume of suspended solids and its biochemical oxygen demand.
6. New plants should be charged a connection fee that varies according to the costs of treating new plant wastes at different locations.
7. Authorities should undertake in-stream aeration where it is an economical alternative to treatment at plants and be involved in the process of deciding on the provision of low flow augmentation. They would provide cost data and perhaps local funds in the latter program.
8. Authorities would be responsible for meeting water quality standards but not for setting them. They could be of assistance in the latter process, however, by providing accurate data on the costs of increased stream quality.
9. Such authorities would be responsible for recruiting and training efficient treatment plant operators, and would provide competent technical personnel to oversee and supervise plant operation.
10. In times of emergency, river basin authorities would coordinate a variety of measures designed to minimize the damage of sudden waste spills, or to take full advantage of unusually high river flows.

¹ Much of the evidence that is available relates to average costs. The same reasons such as economies of scale, availability of cheap land, differing waste concentrations and compositions, which account for the variations in average cost also account for variations in the relevant marginal cost, i.e., the cost of removing an additional unit of pollutant from a constant volume of waste. Much of the following argument will depend on the variability in marginal rather than average cost.

² Federal Water Pollution Control Administration, Northeast Region, New England River Basins, Comprehensive Water Pollution Control Program, Report on Immediate Water Pollution Control Needs, Interstate Waters June 1967.

³ U.S. Department of Health, Education & Welfare, Public Health Service, Division of Water Supply and Pollution Control, Modern Sewage Treatment Plants — How Much Do They Cost? Public Health Service Publication No. 1229 (Washington: U.S. Government Printing Office, 1964).

⁴ The one exception was that costs were the same for all alternatives with the highest water quality standards. This is of little significance since the model was constructed in such a way that this standard could only be met by the highest possible level of treatment from all pollution sources. See Johnson, E. L. "A Study of the Economics of Water Quality Management," Water Resources Research, Vol. 3, No. 2, Second Quarter 1967.

⁵ Kenneth D. Kerri, "An Economic Approach to Water Quality Control," a paper given at the 38th Annual Conference of the Water Pollution Control Federation, Atlantic City, N. J. October 10-14, 1965. Reprinted in Journal of the Water Pollution Control Federation, Vol. 38, No. 12, December 1966, p. 1883.

⁶ If the goal was only to meet dissolved oxygen constraints only, the total cost was \$2,999,000. This was done by eliminating waste discharges into Portland Harbor and by 90% removal of wastes from the only four sources, which were the large sulfite pulp mills. The low cost solution if all municipal waste received at least primary treatment, was \$3,954,000. Both of these approaches cost less than having all dischargers remove 74% of waste which cost \$4,733,000 requiring 85% efficient secondary treatment at an annual cost of \$5,164,000. *Ibid.*

⁷ Alvin S. Goodman and William E. Dobbins, "Mathematical Models for Water Pollution Control Studies," Journal of the American Society of Civil Engineers, December 1966.

⁸ Ralph Stone and Company, Inc., Industrial Waste Profile, Canned and Frozen Fruits and Vegetables, U.S. Department of the Interior, Federal Water Pollution Control Administration, I.W.P. No. 6, Los Angeles, September, 1967.

⁹ A study Commission to Investigate the Problems of Water Pollution Control, A Prospectus, Water Pollution Control in Maryland, February, 1967.

¹⁰ "New Jersey's Anti-Pollution Efforts Are Reviewed," Water Control News, Vol. 2, No. 27, November, 1967, pp. 8-9.

¹¹ From the viewpoint of economic theory it is clear that marginal costs should be used as a basis for the charge structure and not average cost, as is proposed. Otherwise, there will be less than the optimal incentive for process change. However, since the marginal costs of moving to higher rates of removal are much above average costs, such a procedure would tend to generate a politically infeasible surplus in the accounts of the regional authority. Yet, the difficulties implied by using average cost as a basis for service charges are less serious because the authority itself makes many of the optimizing decisions on the provision of treatment capacity.

¹² Some of the ways this might be done would be: 1. to separate the cooling water system from the waste water system and to discharge the former directly to the stream, 2. to replace washing sprays that operate continuously by sprays that are operated only when there is a can or carcass to be washed, and 3. to encourage greater recirculation of water within the plant.

¹³ Cincinnati, Ohio, Division of Water Pollution Control, Water Pollution Control, 1966 Annual Report, Cincinnati, Ohio.

¹⁴ See Arthur D. Caster, "The Cincinnati Sewage Disposal Program," Sewage and Industrial Wastes, August 1955. Caster defends the practice by citing examples of errors in charging that resulted from using less complete sampling approaches.

¹⁵ A Study Commission to Investigate the Problem of Water Pollution Control, Water Pollution Control in Maryland, February, 1967, p. 14.

¹⁶ Kenneth D. Kerri, "A Dynamic Model for Water Quality Control," Journal of the Water Pollution Control Federation, May, 1967, p. 776.

¹⁷ Robert K. Davis, "Planning a Water Quality Management System: The Case of the Potomac Estuary," Water Research, ed. Allen V. Kneese and Stephen C. Smith, published for Resources for the Future, Inc. (Baltimore: The Johns Hopkins Press, 1966), pp. 114-115.

¹⁸ U.S. Department of the Interior, Federal Water Pollution Control Administration, Water Quality Control and Management; Willamette River Basin (Portland, Oregon: 1967).

¹⁹ While this upgrading of the wage level increases the money cost of waste treatment, it does not automatically increase the real economic opportunity costs by the same amount. To the extent that the same workers are employed after and before the change, the real resource opportunity cost is not changed by the wage increase. As better wages attract better people the cost of the pollution abatement program in real terms would increase. However it has been argued elsewhere that these better people are needed for efficient plant operation.

²⁰ For a discussion of the problem of accidental spills on the Ohio River see Edward J. Cleary, "Dealing with Accidental Pollution" The Orsanco Story, published for Resources for the Future, Inc. (Baltimore: The Johns Hopkins Press, 1967), pp. 155-166.

**effluent
charges and
other bonus or
payment
systems**

Many economists have been urging effluent charges as an effective institutional device for organizing pollution abatement.¹ It has been argued elsewhere in this report that one of the major difficulties in trying to achieve an efficient solution to the industrial pollution problem is wide differences in the costs of treating wastes from different sources. Any rule that requires the same level of treatment from all plants would force some to incur very high abatement costs for a relatively small improvement in stream quality. Further, no plant would have any incentive to go beyond the minimum level of treatment required by the regulatory agency. For all plants on the same stretch of a river, it would be best to have each plant treated until the cost to each of them of removing the last unit of pollutant (i.e. the marginal cost) was the same. If one plant were removing a unit of pollutant for 20¢ per pound of BOD, and another could achieve further removal for only 4¢ per pound of BOD, it is clearly possible to achieve the same total removal at lower cost by increasing the level of treatment for the low cost plant and decreasing it for the high cost plant.

Thus for efficiency every plant should remove a unit of pollutant from its waste stream if it can do so for less than a given cost. (This cost ideally is the value of the damage done by the last unit of pollutant). The problem then becomes how to induce such behavior. Two obvious solutions are to pay firms so much per unit of pollutant removed or to charge them so much for each unit they do not remove.

The first alternative has several variants, none of which seem very feasible. One of the largest problems in paying for pollution abatement is determining how much abatement has been accomplished. None of the obvious solutions to this problem seem practical. It is virtually impossible to determine what pollution levels would have been in the absence of the abatement program. Suppose one defines the base level to be the pollution load before the beginning of the payment program. This procedure penalizes exactly those firms that have made an effort in the past to limit their waste discharges. Some firms might even make an effort to increase their pollution in order to have a larger pollution level to reduce. Alternatively, suppose the base level is defined to be the pollution load entering the treatment facility operated by the plant. This method virtually eliminates incentives to the firm to engage in process changes to reduce waste.

An alternative is a treatment subsidy based on the amount of treatment actually performed. This method of subsidy seems preferable in some ways to the current approach based on the cost of treatment facilities. A performance subsidy provides the highest percentage of the costs of treatment for plants that do a great deal of abatement at limited costs. Thus such a subsidy is directed to where it will bring about the greatest amount of treatment. However, for a system of payments for pollution treatment to be effective without some other behavior standard or incentive, the subsidy would have to pay 100% of the treatment costs, otherwise there would be no incentive to the firms to assume whatever share of the costs remained uncovered. However, performance-based subsidies could create serious undesirable side effects. If such payments were above the abatement costs of some firms, this would encourage firms to produce waste and then treat it. Also, polluting firms might continue in business because of the subsidy they received for abatement when they otherwise would not be profitable. Since such subsidies should probably be 100%, the administrative distinctions seem impossible to draw in practice. Hence large payments for pollution abatement do not seem to be an efficient mechanism for improving stream quality.

Charges based on the quantity of pollution produced, seem likeliest to result in efficient pollution abatement. If a firm could remove additional pollution for less than the stated charge, it would tend to do so. The firms which for some reason can do treatment only at great expense will pay the charge instead. Firms which can do more than some "normal" level of treatment at a cost less than the charge will do more treatment. Thus, by buying our pollution abatement at the cheapest market price we are able to obtain it for significantly less cost than under a system of standards that requires uniform cutback. This is the essence of the argument for effluent charges.

The actual damage done by a unit of pollutant depends upon where it enters the river. For a conservative pollutant such as sodium chloride, the concentration at any downstream point is independent of where the pollutant is added upstream.

The further upstream the pollution occurs, the greater the damage since more of the river is affected. For a non-conservative pollutant, the damage done in a particular reach is less the further upstream the pollutant is dumped. Because of the hydrology, the dissolved oxygen problems in a river are often limited to ten to twenty mile river reaches. Pollution added to a river along one of these critical reaches will do much more damage than if it enters the river elsewhere. Efficiency clearly requires that, other things equal, pollution abatement efforts be concentrated on the waste sources doing the most damage. Thus an efficient system of charges would not be uniform along a river.

Such a system, to be efficient, would not be constant over time. It was pointed out in the section on hydrology that large water quality benefits can be obtained by changing the timing of waste releases. To be effective, a system of charges has to encourage firms to undertake the storage, seasonal operation of treatment plants, or short term process changes that will produce such benefits. The simplest way to do this is to have charges that vary with the ratio of the discharge to stream flow. The charge per unit of pollutant flow can also be varied with time of year if necessary.

In order to enforce a charge structure that provides an incentive for seasonal behavior, it is necessary to do sampling over the entire year. This can be very expensive. As the charge levied on a plant depends on the result of the sampling program, a high degree of accuracy and frequency is needed. Such a system would be very expensive to operate. Thus, the information needed to administer an efficient effluent charging system is much more than is needed by a river basin or regional water quality authority. This is true essentially because the gains in going from close to the optimum solution to the optimum solution are relatively small even though the gains in going to the vicinity of the optimum solution from far away from it are great (the response surface is continuous and convex).

As pointed out in the section on basin authorities, a system of effluent charges is unlikely to result in the exact low cost solution. The municipal grant program, the tax deductibility of municipal bonds, and the differing opportunity costs of capital for different firms will produce inefficient variations in response from different polluters. Not reaching the low cost solution need not indicate that the solution obtained from effluent charges is less efficient than would result if a regulatory agency imposed uniform treatment levels. Suppose one firm has more profitable investment opportunities available than the other firm. What can be concluded from the fact that the expenditures for abatement of one firm exceed the expenditures for another firm, while both firms eliminate the same degree of pollution? Such a situation does not imply that a reallocation of pollution control investment is an improvement without a transfer of funds between firms. Thus the fact that differences in ability to borrow, etc. cause the response to a given effluent charge to differ from the minimum cost solution is not an argument against effluent charges if the alternative is regulation. Indeed, this difference in response is an advantage over the uniform cut back solution. A basin authority scheme is superior to both, as it permits utilizing the minimum expenditure solution while seeking capital from the market at low interest rates.

Effluent charges as a means of improving water quality involve several difficulties. They are strongly opposed by the major pressure groups interested in pollution control: industry and conservation groups. Industrial opposition is not difficult to understand. Under a system of regulation, the polluting industries have at most to pay for the cost of treatment they actually perform. With effluent charges, they have to pay both for the treatment they do and additional charges for the residual wastes which are not removed by the treatment. Thus even if the treatment itself is accomplished more efficiently, it is likely that the total costs to industry will be greater with effluent charges than with a regulatory system. For instance, one study of the Delaware² showed that with effluent charges high enough to produce the required improvement in dissolved oxygen, (10¢ per pound of BOD) the treatment undertaken by industry would cost about \$8.6 million while industry would pay an additional \$7.3 million in effluent charges for the residual waste discharged into the river. Thus industry's opposition is understandable -- despite the efficiency of the resulting solution in terms of real resource use. The study confirmed the superior efficiency of effluent charges, showing that the total cost of treatment undertaken to maintain a given water quality was very much less with an effluent charge system than with required uniform treatment.

Conservation groups have opposed effluent charges in part because they doubt that the charges would be set high enough to be efficient. They have also used the argument that effluent charges are a "license to pollute." This last point is difficult either to interpret or accept. A complete ban on the addition of BOD and other wastes to all waterways would cut American industry literally by half. Thus some residual pollution must be allowed that cannot be economically treated. The problem is not one of whether to license or allow pollution. The continuation of American industry requires that some "licenses to pollute" continue to exist. The question is whether such licenses should be given away free or charged for on the basis of their worth. The relevant substantive question is, are effluent charges efficient and can they be set high enough to be effective, not are they "a license to pollute."

A major problem with effluent charges is that we cannot say with certainty what level of charges are needed to meet the stream quality standards. There has been only one study dealing with this problem and it suggests that the range of uncertainty involved is wide.³ The point is that the two separate problems of what stream standards to set and what level of effluent charges to use to meet such standards are each more difficult to solve than the question of what level of effluent charges are needed to inform polluters of how much it is worth to society for them to reduce their pollution. Consider the problem of corrosives like sodium chloride. An efficient approach to the problem of dealing with these pollutants would involve first determining how much damage a unit of pollutant causes. Once a figure had been determined for the damage done to pipes, bridges, etc. by a pound of sodium chloride, this could be set as an effluent fee. Polluters would then take measures to limit salt discharge only if the cost to them was less than the benefit to the users of the water. This is the desired outcome. We do not know in advance the extent to which dischargers will respond to the charge and hence the final concentration of sodium chloride in the stream. But there is little need to know this. This procedure is much more efficient than trying to set a chloride ion concentration as part of the stream standards, such that the costs imposed on the dischargers in meeting the standards will not be either greater or less than the benefits to the water users. Also, if it is decided to meet stream standards by effluent charges, it will be extremely difficult to set the correct level of such charges in advance — the level which will produce desired stream standard as a result of the induced firm response.

The above case is fairly simple because the charge for the damage done by a unit of pollutant is roughly independent of the total quantity of pollutants in the stream. (In technical terms, the damage function is linear). BOD is a more difficult problem. The damage done by a pound of BOD will be greater if the stream has already been sufficiently polluted to exhaust its assimilative capacity. Thus one cannot say exactly how much it is worth to eliminate a pound of BOD without an estimate of what the pollution load would be after the effluent charges were established.

One way to handle this problem is by what is called an iterative process. An initial level of charges is set. If it appears too high in light of the observed response, it is reduced; if too low, it is raised. This process of adjustment is continued until the optimal charge level is reached. This is an inefficient process. Treatment plants are very capital intensive, and if one is built for a lesser or a greater degree of treatment than subsequently seems justified, little can be done about it later. The process of searching for the correct level for effluent charges would involve some costs, many of which would be avoided by the proposed basin authority scheme. It would be able to plan in advance for the removal of the appropriate amount of waste in the least-cost manner.

To meet stream standards, effluent charges would have to be relatively high. At levels below the minimum average cost of waste removal, effluent charges can be expected to produce little waste treatment.⁴ A few plants that have cheap land available for oxidation ponds will install them. The remainder will continue to dump untreated wastes. Even if an average level of BOD removal of say 40% were sufficient to maintain the stream oxygen standards, effluent charges that produce the above result would be unsatisfactory. There are certain problems of water quality that would be very difficult to solve by means of effluent charges. Suppose one based such charges on BOD. Some firms might do no primary treatment at all, which would lead to floating matter and suspended solids from their wastes being discharged into the stream. Such a situation would be extremely obnoxious, and should

be avoided. Since there is no simple measure for floating matter that is related to its harmful effects, there is no way to handle this problem in the effluent charge framework. Thus even with BOD effluent charges, certain administered standards to insure some primary treatment from all plants might be required. Toxic wastes or other problem chemicals too would probably have to be dealt with through enforcement.

To summarize, effluent charges are an efficient system for inducing industrial waste treatment and waste-abating process changes. They should be given very serious consideration as a possible device for improving water quality without too much detailed central control and direction. However, a Regional Water Quality Authority seems to have some advantages over a system of effluent charges, especially for involving technically less difficult decisions to achieve low cost solutions. Authorities would be able to exploit river hydrology in a more efficient manner, and take advantage of the economies of scale of large treatment plants. They could also provide river basin management in an emergency. Given the high administrative costs of even a constant annual service charge, the administrative costs of a sophisticated effluent charge system seem close to prohibitive unless research and development lowers the costs of sampling and monitoring below current levels. Basin authorities also have much to recommend them over effluent charges as a framework for dealing with the problems of hardship cases and for upgrading treatment plant operator quality. Such authorities offer firms several extra advantages by relieving them of the capital costs and administrative burden of treatment facilities. Thus although effluent charges have much to recommend them, the creation of regional or basin wide treatment agencies appears to be the preferred strategy for attaining water quality in an efficient and equitable manner.

¹ See Allen V. Kneese, *The Economics of Regional Water Quality Management*, op. cit. for a persuasive discussion.

² Johnson, E. L. "A Study in the Economics of Water Quality Management," *Water Resources Research*, Second Quarter 1967. Vol. 3, No. 2, p. 291 ff.

³ *Ibid.*

⁴ Frankel, *Economic Evaluation of Water Quality*, Sanitary Engineering Research Laboratory, University of California, Berkeley. SERL Report No. 65-3 January 1965, produces a series of curves for annual costs of treatment versus percent BOD for municipal sewage. The average cost curves these imply are conventional "U" shaped ones. The removal of low levels of waste through sedimentation has a relatively high cost. The addition of secondary treatment has a lower marginal cost per point of BOD removed. It is not practical to pass raw sewage through a trickling filter because of problems with filter clogging. Likewise the power required to keep large, relatively high density particles in suspension makes the use of activated sludge impractical without preliminary sedimentation. Thus, minimum cost per unit of BOD removed is obtained for a combination of primary and secondary treatment designed to remove 80-85% of the BOD load. A similar situation seems to hold for most organic industrial wastes.

**scarce inputs
to pollution
control**



To the extent that the implementation of any water pollution abatement program requires a significant quantity of raw materials, specialized equipment, or trained personnel, policy makers should consider the effect of a short supply of these inputs on the ease and efficiency with which the program could be carried out. The pace of the pollution abatement effort envisaged in the Water Quality Act of 1966 implies that substantial new investment in the construction of pollution control facilities must be made in the next few years. If there are serious supply shortages of the necessary factors of production, it may be impossible to comply with the schedule proposed in the Act for attaining pollution control standards. Also, such shortages might lead to significant price increases for these factors if the demand for them generated by the program is greater than the available supplies. Therefore, increasing the supply of the inputs needed for pollution control is an indirect but important means of assisting industry to comply with the established water quality standards. In light of these considerations, the following section will discuss the supply of materials and manpower necessary for pollution control, the magnitude of the supply problem, and the appropriate response of government for aiding industry to attain pollution control objectives at a reasonable cost, within a reasonable length of time.

The first task is to identify those resources required for the water pollution control program which might be subject to significant shortages as the country attempts to design, construct and operate an expanded number of sewage treatment facilities. The initial selection of items discussed here developed from both a systematic evaluation of the resource requirements of the program and from views held by government agencies and outside organizations as expressed through published studies and actual business policies.

After recognizing the potentially crucial resources, the next objective is to analyze the present supply and demand situation within the context of the pollution abatement program, and to estimate how both the supply and the price might be expected to change over time in response to market shortages. It is necessary to realize that exact and dependable data is scarce and that any projections are at best conjectural, since actual demand will depend upon policy decisions not yet made.

For the purposes of this study, the supply situation is broken down into three categories: material, sewage treatment plant operation, and engineers. The section about material will be devoted specifically to electric motors and copper. Plant operators and professional engineers are treated separately because the nature of their supply markets and their roles in the pollution program are both very different.

In all three of these categories, the important consideration is time. There is little doubt that given enough time the economy would easily be able to generate sufficient quantities of all these resources. The crucial problem is whether or not they will become available in sufficient amounts, sufficiently quickly and at low enough price to enable the nation's water pollution abatement program to proceed in an efficient and equitable manner.

An inquiry among design consultants for sewage treatment plants indicated that there might be material shortages in several areas: electrical, control, and specialized pumping equipment; and that there might also be a shortage of copper for use in these devices and for tubing. Although none of the firms contacted were unable to fulfill contracts because of these shortages, they were experiencing rising prices and long delays in equipment deliveries. To clarify the situation, additional conversations were held with some of the major pumping equipment, electric motor, and control device manufacturers and construction companies. Some of these firms expressed concern specifically for the availability of transformers, switch gears, relays, porcelain insulators, pneumatic control devices, and electric motors and compressors.

Copper has been used for tubing and as a base metal for electrical and mechanical control devices because of its high malleability and its susceptibility to chemical

material

plating processes. Both of these attributes reduce the amount of labor necessary to produce finished goods. Although copper is priced higher than its substitutes, the low associated labor costs often make it the most economical metal. Copper is also used in electrical motors and devices because of its desirable electrical-conductive properties.

A few of the firms believed that, aside from a shortage of production capacity, one of the primary causes of delays and price increases is an underlying shortage of copper. The concern about shortages in the supply of copper for domestic use stems both from the existence of several prolonged strikes affecting a number of the world's major copper mines and from the increased demand on copper for military usage. At the moment, companies producing defense items are given priority for copper. A copper shortage would be relevant to the pollution abatement program because of the use of copper in tubing, control devices and electrical wirings all of which are used in sewage treatment plants.

In fact, it does not appear that the shortage of copper is crucial to the water pollution program. In most sewage treatment plants, the heavy pipes are made of cast iron, rod iron and steel. Copper tubing is usually used for piping water for the personal consumption of the treatment plant staff. The cost of this piping represents at the most 0.2% of the total construction costs of the plants. Recently, even this small amount of copper is being replaced by polyvinyl chloride (PVC) and other plastics.

A much greater use of copper is in the electrical and mechanical control devices used for instrumentation. The costs of copper in those items only amounts to 1% of the total construction costs, and there is substitutability in this area as well. Even after current strikes are settled, the world copper supply may continue to be strained and copper shortages may continue to hamper production scheduling.

Some of the larger companies involved in manufacturing control devices have switched to using aluminum instead of copper, although it is not quite as satisfactory from a technical viewpoint. Aluminum costs more per pound than copper, but it is also less dense and therefore it takes fewer pounds to make the same equipment. Aluminum is not as malleable as copper, which implies higher associated labor costs. Aluminum does not take well to plating processes and the plating facilities necessary are often quite costly. In spite of the disadvantages, there has been a significant shift to aluminum for the production of control devices.

Delivery times of most capital goods used in sewage treatment facilities have been increasing over the last few years. Items such as transformers and switch gears which took 8 to 18 weeks for delivery during the recession of 1962 are now taking 40 to 75 weeks. Porcelain electrical insulators, a product which in many instances requires little design work, is taking 2½ to 3 years for delivery. The slow delivery of this last item is causing some construction companies to turn to Japan, France and Sweden to meet their needs and schedules for insulators.

These delivery delays are substantial and have led to the question as to whether this deficiency of production capacity will be long-lived. Current delays retard plant construction and if they were to increase, it might be necessary to modify the scheduling of the pollution abatement program. Many of the companies contacted, including pump manufacturers, electric motor manufacturers, and control device manufacturers, said that they were expanding existing facilities and building new plants. Also, they said they did not anticipate any material shortages within the next five years that would impede their production.

Although the government has instituted a manufacturers' priority list for the usage of copper, those companies which produce defense goods usually produce domestic goods and can obtain copper for non-defense items. No doubt some portion of the price increases for equipment is due to competition for resources, but much of it is also due to rising labor costs. The competition with defense usage for some items, especially control devices, has caused some of the recent backlog. The expansion of facilities should alleviate some of the shortages.

In part, these backlogs are not fully representative of the market demand. When it became apparent that there would be increased competition for various goods,

many companies began to over-order and over-stock these items. The market is now beginning to adjust itself so that cancellations of orders are beginning to come in. However, this method of planning ahead and putting in advance purchase orders on long-lead items as soon as the design specifications are known minimizes the total construction delays.

Observed delays are the normal result of the behavior of a capital goods industry which builds up back orders at cyclical peaks. This backlog of orders acts as a protective cushion for the firms when demand slackens. Production facilities are not expanded (except very slowly), because manufacturers run the risk of being left with excess capacity when the demand for investment goods drops precipitously in the event of a recession. In fact, some backlogging may be efficient in the long run.

In spite of these backlogs, the pertinent question is whether or not the supply of material is responsive to market action. Equipment firms seem optimistic about the long-term growth of the market. It seems reasonable that as firms become confident in the strength of potential market demand, they will be more willing to expand capacity to reduce the level of back orders. In any case, the shortages observed are really part of basic economy-wide supply and demand imbalances. Sewage treatment plant demands are only a small segment of the relevant market, and any water quality program will have only a negligible impact on the underlying situation in these basic capital goods sectors.

In short, since material supplies respond well to market conditions and since pollution control equipment is only a small percentage of the relevant market, there appears to be little justification for government programs to enhance such supplies from the perspective of scheduling the nation's water pollution control program.

Given the anticipated growth in capital facilities for sewage treatment in the near future, some attention must be devoted to the problem of recruiting sufficient competent personnel for the operation and maintenance of these facilities. At the moment, there seems to be some shortage of qualified sewage treatment operators. Even at the current level of pollution abatement efforts, the efficiency of the program is being injured by the lack of people willing to fill these positions. Investigation reveals that, in the near future, industrial and governmental efforts to comply with the new water quality standards might send the operator situation to crisis proportions.

sewage treatment plant operators

Because of their similarity to the functions of industrial operators, a study of the present characteristics of the municipal sewage treatment plant operators provides insight into the nature of the operator shortage. The municipal situation is especially relevant if the recommendations elsewhere in this report for regional water quality authorities are followed. In a recent document prepared by the F. W. P. C. A., it was estimated that, on the basis of increased authorizations of Federal funds for municipal sewage treatment plant construction, there will be an increased demand of 150% over the 20,000 currently employed municipal operators by 1972.¹ The existing municipal operators, responsible for maintenance, operation, and adjustment of the sewage treatment plant to changing environmental conditions are, as a group, underpaid and understrained. In most instances, their quality has been notoriously low; in extreme situations, multi-million dollar treatment plants have been not only mismanaged, but seriously damaged by incompetent and untrained personnel.

However, the gross demand estimates and the isolated reports of plant mismanagement do not fully disclose the nature of the operator supply problem. Both the quality and quantity of available operators are not uniformly low throughout the nation. Conversations with a number of state and local water pollution agency officials revealed quite distinct regional differences in the characteristics of the operator supply. In New England, for example, there is a crying need for operators and those few who apply for positions are, for the most part, unskilled and unmotivated to learn. Currently, the multi-million dollar Deer Island treatment facility in Boston, Massachusetts is dumping untreated sewage into the sea because the state has not

been able to attract competent personnel. In the Great Lakes region the states are not experiencing a shortage of applicants, but their operators lack adequate training. However, California and Oregon public authorities are enthusiastic about the number of applicants, their skill levels, and their attitudes. These operators are competent and eager to enter training programs to further their skills. In Oregon, the career interest is very much higher and, in fact, there are waiting lists for operator jobs.

The predominant factors for the regional differences in interest, skills, and motivation among current operators seem to be the salary levels of the operators, the public attitude toward water quality, and to a lesser extent the operator training facilities available. Of course, these factors are all closely related. In some of the highly industrialized Eastern cities, where traditionally the wastes from textile and paper mills have been dumped into the rivers and streams, the operator salaries are surprisingly low, often in the \$3,000 to 4,000 per year range. Public concern for upgrading the quality of these long violated rivers has not been sufficiently intense or widespread to cause important administrative changes in the water pollution control program. In the midwestern regions and, in particular, near the complex of streams and rivers around the Great Lakes, the public is mindful of the need for clean water. The importance of recreational water facilities to this region has apparently resulted in conscientious government water quality programs. Treatment plant operators are paid reasonably attractive salaries, ranging from \$5,000 to \$9,000 per year. On the west coast, where water supply and water quality have long been major public issues, the operators receive salaries competitive with industry. Their jobs have higher status than similar positions elsewhere: salaries of \$7,000 to \$10,000 a year often attract personnel whose training in other areas can be substituted for training in sewage treatment plant operation.

Another factor contributing to regional differences is advancement opportunities. The observation that these opportunities correlate highly with salary levels is a very relevant piece of information. In order to be advanced, an operator must have the ability to perform management functions and to exercise managerial discretion required of higher-level positions. In higher salary areas which attract competent personnel, administrators are able to find intelligent and adaptable operators who can be advanced to supervisory and managerial tasks. Those men hired at low salaries in other regions often appear unable to cope with the more difficult responsibilities. Clearly a feedback effect is at work. The higher salary levels attract initially those people who are capable of handling further responsibilities.

Training programs for operators are, of course, very important to an effective clean water plan. These programs help attract and prepare new operator applicants for their jobs; they also prepare existing personnel for more responsible positions. Without outside operator training courses and facilities and adequate on-the-job training programs with the personnel to administer them, the nation will have less than adequate performance, and certainly less than maximum efficiency, of sewage treatment operation and maintenance activities. In general, however, the training programs in the areas reporting high quality and quantity of operators are not appreciably different from the training programs in areas with personnel difficulties. Again, the key factor seems to be the type of personnel attracted to the job in the first place. Those to whom high salaries are offered may come to the training programs with more ability and motivation to learn than those who receive lower salaries.

Licensing and certifying operators to set minimum standards, like training programs, would help to raise the status of operator's job. The training programs and licensing are only effective if accompanied by sufficient economic incentives such as wages and advancement opportunities to attract competent personnel. In some instances, licensing can help raise the salary levels of competent personnel. New York, Michigan, and New Jersey, who have relatively effective clean water programs, require licensing for sewage treatment plant operators. However, operator licensing, especially when it is not a strong program supported by training, may not be effective. Indiana, for example, has had voluntary certification for years but it still faces a shortage of qualified operators. Indiana's proposed legislation for 1968 will require mandatory certification of operators, yet the law still makes no provision for salary increases.

The question to be asked is why in many regions salary levels do not respond to the obvious demand for qualified operators. The reason is that, as it now stands, the operator labor market has several features which create wage inflexibility and limit the scope of the labor pool. One factor is a feedback phenomenon which occurs at low salary levels. That is, those people who accept the low salary positions are often less competent and public officials are reluctant to offer unqualified operators a higher salary. Secondly, unlike the industrial price system for goods and services, or for engineers, both of which are well organized on the national level, the salary schedules for state and municipal employment are limited by the formal structure of government and civil service salary practice. A wage increase in any one area of local government puts pressure on administrators for salary increases in other jobs in the city, while funds for massive salary increases are usually not available. Another limiting factor is that the operators are drawn from the local labor pool. Although this may be politically beneficial, in some situations it tends to limit the supply of applicants. Finally, the existing federal support programs for water pollution control have a strong capital intensive bias. Little if any funds are designated to subsidize operating costs such as the salaries of operators.

The conclusion of this study is that the supply of qualified operators clearly responds to increases in salary. However, without these salary increases the situation is unlikely to become appreciably better in spite of efforts in training programs and certification. In light of these considerations, here are several recommendations for improving the supply of competent operators.

1. In view of the potential shortage of operators, a variety of government efforts to facilitate the training of additional operators is desirable, particularly the following:
 - a. Existing government job training and retraining programs like the Job Corps and other Poverty Program efforts should be used to help provide additional personnel. This would help fulfill the goals of the latter programs as well, since it would direct trainees into a sector with serious labor shortages and rapidly expanding employment opportunities.
 - b. Further aid should be considered to assist in establishing additional training programs and facilities especially designed for operator training. Such facilities could be operated by other levels of government after initial Federal assistance and could provide both comprehensive training and retraining programs.
2. A serious study should be conducted of the supply and demand situation in the area of sewage treatment plant operators. Such a study would suggest the types of ability and background available in the labor market to fulfill operator jobs. It would also make explicit exactly what kinds of skills and training are needed to adequately fill job vacancies. The information developed by this study could be used as a basis for the development of detailed curricula for training programs of various types. The materials and plans for such courses could be made available to local governments and other training agencies to assist them in efficiently conducting existing training programs.
3. Consideration should be given to establishing systematic regional and national exchanges of information on operator job vacancies and salary situations to facilitate placing people from the training programs recommended above.

The designer of an incentive plan for industry to achieve water pollution abatement must not only encourage an increase in the demand for abatement facilities, but must also ensure that the demand can be met by an increase in the supply of abatement facilities. This section will concern possible shortages in the supply of the sanitary engineering services which will be needed to design, operate and administer pollution control operations.

There is reason to be concerned about the supply of sanitary engineering services. Basic economic theory indicates that any increases in the rate of growth of the stock

sanitary engineering services

of treatment facilities will require an even more rapid growth in the sectors and industries that produce such facilities. That is, the planned high rate of growth in abatement plant construction could conceivably strain the resources of the firms that design and construct treatment facilities. In addition, the current pollution control program will place increased burdens on state, local and federal agencies charged with the responsibility for the enforcement and operation of the new national system of stream standards. Furthermore, if additional treatment facilities are to be operated efficiently, there will have to be additional personnel to operate these facilities. In particular, any effective water quality program will require additional sanitary engineers.

The focus here is on sanitary engineers because there seems little reason to believe that general civil or mechanical engineering services are in short supply for the pollution abatement program. Treatment plant construction is only a small percentage of the national construction industry which supplies these skills.

substitutability

Before making any judgments as to the supply and demand situation, it is necessary to consider explicitly the question of how easy it is to substitute other engineering knowledge for specific sanitary engineering training. The answer to such a question must necessarily be qualitative and inexact. However, it appears that trained professionals can learn to perform sanitary engineering functions in a relatively short time, either through some specialized formal education or on-the-job training that allows them to become acquainted with specific problems and methods in the area.

One reason for this substitutability is that much of the work done under the heading of sanitary engineering is not specific to that field. Rather, sanitary engineering usually applies the knowledge and techniques of several areas to particular waste disposal problems. For example, the design of secondary treatment plants requires knowledge of the bacterial life cycles on which the plant's effectiveness depends. Similarly, much of the detailed design of treatment plants is straight civil engineering. Further, some of the basic processes are similar to many other chemical processes and can be executed by someone with appropriate general background and a modicum of specific training. In industry many of the engineers who supervise the operation of waste treatment facilities are the same personnel who oversee general plant operation as well.

However, some functions (like overall plant design and inspection for a federal grant program) seem to have much less opportunity for substitution. These areas tend to require experienced personnel as well as individuals with the combined technical background in hydrology, chemistry, bacteriology and the design of specialized equipment that is usually possessed only by a sanitary engineer.

supply

It is very difficult to decide which individuals to call sanitary engineers for the purposes of this enquiry, because many of the people who call themselves sanitary engineers come from other engineering backgrounds. It is even more difficult to decide what to include in the supply of sanitary engineering services. Many of these services can be and are supplied by individuals who do not consider themselves to be sanitary engineers but rather chemical, civil or mechanical engineers. At any rate, a rough estimate would be that somewhere around 6,000 professionals now work primarily at providing sanitary engineering services, with all the qualifications that such an inexact number must contain.²

The flow of engineers from specifically sanitary engineering programs is somewhat easier to ascertain. Current estimates are that between 215 and 300 individuals receive sanitary engineering degrees each year.³ Not all are available for employment, of course, since some go on to further education or into teaching. The number of degrees awarded has grown by over 20% per year in the last few years, a rate about twice the national average growth rate for engineering degrees in general. The recent acceleration is to be contrasted with a growth rate for new degrees of about 3% per year during the 1950's.⁴

Any discussion of supply of sanitary engineering services must also concern the less formal methods that in fact produce many of the individuals who do this work.

Other engineers can learn sufficient sanitary engineering in a relatively short time. At present, many firms do on-the-job training to provide the requisite personnel for their own operations. In some cases this takes the form of actual training programs. Part time study or short term intensive work are other alternatives. In view of these circumstances, the figure of 200-300 new sanitary engineers per year does not really capture the relevant dimension of the situation.

What are the essential characteristics of the demand for sanitary engineering services? In the first place, the basic demand is not for these engineers, per se, but for clean water. The demand for clean water seems to be relatively insensitive to its price. If sewage treatment plants were to rise in price by 10% or so, it seems quite unlikely that this would make any appreciable difference in the number of such facilities eventually constructed. In fact, under the current administrative structure where firms and municipalities must meet stream standards, the demand for clean water and treatment facilities seems to have been structured so as to be almost completely insensitive to price changes. Thus, the demand for sanitary engineers depends upon (because it is derived from) the demand for treatment plants and other clean water programs. The price sensitivity of any such derived demand depends not only upon the demand for the object it is derived from, but also on the possibilities of substituting other kinds of items for it. Thus, the price sensitivity (or in technical terms price elasticity) of demand for sanitary engineers depends in part on the availability of substitutes. Because of the ease with which such substitutes can be used in sanitary engineering, any scarcity in sanitary engineers and a concurrent raise in salaries offered sanitary engineers will tend to shift some of the demand to other professionals. It becomes economical to use other types of engineers because of their lower price despite their lower skill. Thus, a firm would use non-sanitary engineers for design work once the cost savings on cheaper design were greater than the expense of the losses in efficiency from lower quality design.

Since design is such a small percentage of the cost of new plants, there are limitations to the impact of this effect. In supervision and administration too, there seems to be some room for substitution if the price for sanitary engineering service rises especially high. Some of the administrative work in planning and supervising treatment systems or river basin authorities might be done by men with training in economics, systems analysis, operations research, or applied mathematics. Similarly, it might be economical to have technically less skilled individuals with relevant experience fill some of the administrative positions which are now currently held by experienced engineers.

The acceleration required in the construction of treatment plants is substantial if water quality standards are to be achieved in 5 to 7 years. Currently about \$600 million worth of municipal sewage treatment facilities are being constructed each year. The estimated cost of new facilities is over \$7 billion. Thus, it would appear that the production of treatment plants will have to increase by a rate of about 10% to 20% per year to achieve these goals in the specified period of time. Such rapid expansion could put a strain on design facilities. This pressure could be less severe than it appears, however, because it would seem that only a few engineering man years are required for each million dollars in facilities constructed.⁵

Some indication of the pattern expected to develop in response to rapid program expansion can be found in the current supply and demand situation. Those would-be employers of sanitary engineers who can afford to pay the highest salaries should have the least difficulty in recruiting adequate personnel. It is not large design and consulting firms, but municipalities with rigid, low salary structures that are currently having the most difficulty in recruiting. This situation is indicative of the smooth functioning of the market for engineering manpower. In this market, information about job opportunities is relatively well diffused, and workers are intelligent, sophisticated and mobile, so that the supply of engineering services should be quite responsive to price differentials.

In light of this discussion of supply and demand, what conclusions should be drawn about future shortages in the area of sanitary engineering because of the acceleration of the nation's pollution abatement program? First, it would seem that salaries

demand

future interaction

will rise in relation to other engineering specialties. This will happen more in industry than in government because of the greater flexibility in the wage structure in private firms. As the price for sanitary engineering services rises, both supply and demand can be expected to respond. More civil and chemical engineers will switch to sanitary work. They will take formal courses, utilize firm training programs, or enter through on-the-job instruction. Degree programs in sanitary engineering can be expected to continue to expand, perhaps even at a faster rate than the one observed in the recent past.

At the same time, entities which demand such services will be willing to accept available close substitutes as the price for the existing stock of personnel rises. They can be expected to shift work loads so as to allow non-sanitary engineers to do some of the design and operating work that specialists formerly performed. Some firms will lengthen backlogs and postpone completion dates as they take on work more rapidly than they can expand their staffs. On the whole, the market should operate reasonably well to equate supply and demand over the transitional period. Yet, there is little doubt that during the transitional period some employers, especially those unwilling or unable to offer wages at the rising market rate, will be unable to hire their desired complement of engineers. Firms will also become willing to do more on-the-job training, or to share some of the costs of formal education for would-be entrants into sanitary engineering from neighboring fields.

Experienced design, administrative and supervisory engineers with strong sanitary engineering background can be expected to be in especially short supply. Mature and practiced skill is not a commodity whose supply can respond quickly to price increases, nor are substitutes as readily available as they are for less skilled personnel.

What can the government do to facilitate the response of sanitary engineering services to rising demand and thus help the market adjust more smoothly lessening any transitional shortages? At the moment the vast bulk of sanitary engineering students in formal programs (80%) are supported by Federal funds of one sort or another.⁶ Some increase in support for graduate education in sanitary engineering might be helpful in this respect. Since most graduates of these programs receive master's degrees and many come from other engineering backgrounds, some impact could be expected in about one to three years. But the number of men who can realistically be expected to be trained under all such programs are not going to make a revolutionary impact on the overall supply and demand situation. A more fruitful approach would be to explore the possibility of special short term programs designed to facilitate the entry of already practicing professionals from closely related areas into sanitary engineering. Perhaps programs that combined formal study with on-the-job training and work experience would be best.

A word of warning is in order, however. At some point the nation will begin to catch up and satisfy the backlog of pollution control plants that need to be constructed to attain water quality standards. As this occurs the pace of new investment in treatment facilities should decline somewhat to the level required to provide for continued population and industrial growth. This development should lead to some decline in the demand for new engineers in the sanitary field, and hence some decline in the need for facilities and programs to train them. Thus any federal assistance program should be seen as temporarily designed to deal with transitional problems. Care should be taken to avoid creating facilities for training sanitary engineers that might become overcapacity in less than a decade.

One of the clearest points to emerge from the analysis undertaken for this report is that the capacity of the market to respond depends heavily on the exact pace of pollution control investment envisaged. Increasing the number of years in which to accomplish the national program from five to seven or eight makes the potential adjustment seem much more reasonable. In light of the fact that appropriations for municipal grants for pollution control are below initial authorizations, it would appear that the initial five-year timetable is already being implicitly stretched out, at least to some degree. Considering the capacity of the economy to produce and operate treatment plants, it may well be that supply limitation would have forced a delay of a few years if the five-year abatement program were undertaken exactly as envisaged. It is not clear that there will not be long delays even under current circum-

stances. However, neither great pessimism nor massive federal intervention seems warranted at this time.

In light of the discussion the following recommendations seem justified:

1. Some increase in Federal funds for graduate education in sanitary engineering might be desirable; however, the program should expire in a few years, once the transitional adjustment had been completed.

2. Efforts should be made to developing short-term, intensive courses of study to help new entrants from other specializations enter the sanitary engineering field. Cooperation between private firms, government agencies and the universities would seem advisable — allowing trainees to combine study with work experience. If the costs to trainees of participating in such programs were lowered by support from government or industry, new entrants would presumably be more willing to participate.

3. Greater efforts should be made to educate engineering undergraduates and graduate students about the advantages of a career in sanitary engineering and to point out how rapidly the field can be expected to expand in the near future.

4. River basin authorities to treat all wastes should be supported, because they could provide adequate salaries to technical personnel for supervising the operation of treatment plants and providing consulting services. If any one sector seems most likely to be short of needed engineers, it is the municipalities which have less flexible salary schedules. By taking over municipal plants, basin authorities would avoid the disadvantages of undertrained staff and the limitations of restricted municipal salary levels.

¹ Manpower and Training Needs in Water Pollution Control, Senate Document 49, August, 1967.

² There were then about 5600 sanitary engineers in 1955, according to U.S. Department of Health, Sanitary Engineering Manpower, Public Health Service Publication No. 703.

³ Rick Linvil, Dean of Engineering, Clemson University and Chairman of Sanitary Engineering Education of the American Academy of Environmental Engineering estimated 300. The figure 215 comes from Table 4, Engineering Education, Sept. 1967, and includes 30 schools while there are at least 50 programs. See B. N. Hanes, "Manpower to Fight the War on Water Pollution," *Water and Sewage Works*, August 1967.

⁴ Hanes, *op. cit.*

⁵ Private Communication from Camp, Dresser and McKee, Inc., Boston, November, 1967, and Local Public Facilities Needs, p. 77.

⁶ Hanes, *op. cit.*

conclusions and recommendations

**marginal
plants and
hardship cases**

Any national program of pollution control must deal with the possibility that the expenses of waste abatement will cause the managers of some plants to cease operations rather than meet the costs involved. Although programs of aid to the firms who operate such plants are "assistance" rather than "incentives," the policy questions involved are considered in this report because they so closely relate to the question of choosing an industrial incentive scheme, and to the general problem of organizing an efficient and effective program to attain the nation's water quality objectives. In analysing this problem, the first question posed is what kinds of firms are likely to be seriously injured by pollution control expenditure and why. The meaning and implications of such injury are then discussed in terms of social goals. Next, general guidelines are developed to shape policy choices and some practical difficulties are suggested. Finally, this report recommends those assistance schemes which might be both feasible and socially efficient in dealing with the problem.

It is important to clarify at the beginning of this discussion that hardship cases are not simply those plants that will have to spend a great deal on pollution abatement, or even those plants whose abatement costs are high per unit of output. In identifying hardship cases, the problem is to find those plants whose costs of pollution abatement per unit of output will be significantly higher than the abatement costs incurred by the competing firms in the same industry. When waste abatement imposes costs on an entire industry and on the producers of any close substitutes, market forces tend to raise the prices received by the industry to cover the increase in production costs resulting from pollution control. However, when a plant has higher control costs per unit of output than its rivals, the costs of the plant tend to increase more than the prices it receives. In that case, the profit margin on the plant's operations is collapsed. If that margin were small to begin with, the plant might become unprofitable, and hence be threatened with having to close down. Consequently, there is no basis for identifying as hardship cases all of those instances where pollution expenditures are high relative to the value of the output of the plant. If they are high for all plants producing goods that compete in a given market, prices should adjust accordingly.¹

Among all hardship cases, there are those which can be termed "marginal" and those which can be characterized as "failing." Marginal plants are those which would be viable if present market conditions did not change radically, excepting the costs of pollution control. Failing plants are those which would be unable to continue in profitable operation in the long run with or without the burden of waste abatement spending.

From an examination of several industries which might suffer from having to assume the costs of abatement, it appears that many of the vulnerable plants are small relative to other firms in the industry. They also tend to be older, and to use older technology or processes. These empirical findings confirm similar estimates of the nature of hardship cases made after considering the general technology of waste abatement. As discussed in a previous section (see Economies of Scale), small size itself generally leads to high average costs for pollution control. In addition, older plants tend to be located on more crowded sites while newer ones are more likely to have inexpensive land available for land intensive treatment methods, which are often less expensive, (see Land Intensive Methods above). Finally, many of the newest plants were built with some waste abatement facilities from the beginning, or they utilized newer processes that generate less waste per unit of output.

In theory, the distinction between a failing firm and a marginal firm should help formulate assistance programs. Although workers in both types of plants would lose their jobs if operations ended as a result of pollution control expenditure, only for the marginal plant would assistance with abatement costs prevent unemployment in the long run. For the failing plant, the effect of the aid would be simply to postpone closing for several years. The relevant question to answer at this point is how long a typical failing plant would take to close because of normal market pressures. Yet it is clearly impossible to make any valid general prediction on this point.

identifying plants that might be hardship cases

In practice, it would appear to be impossible to distinguish between failing and merely marginal firms for policy purposes. How can one predict in advance which low-profit firms will be viable in the long run? In some sense, the individuals best able to make such a distinction are the managers of the firms which operate the plants in question. Therefore, although it is not practical to incorporate the distinction between failing and marginal plants directly into an aid program for hardship cases, if such a distinction is felt to be desirable, the program should be framed so that some self-selection takes place among industrial managers.

Case studies of selected industry sectors indicate that many of the plants which might apparently cease to operate because of the additional costs of water pollution abatement are in the failing category. In general, these plants are often at a competitive disadvantage with respect to many other factors in addition to abatement costs, such as location, management, and technology. In fact, pollution abatement may not be of primary importance in their decision to close, but may only serve as a convenient excuse to do so.

the impact of hardship cases

In order to make intelligent recommendations on what policy to follow to alleviate hardships caused by a plant's closing down, we must examine exactly what these hardships are and what are some of their characteristics. The most serious impact of a plant closing is that some people are put out of work. There is a serious waste of productive resources as well as psychological damage when a worker not gainfully employed is forced to seek public assistance. The social and human capital invested in these workers through their training and experience is wasted.

The problem of unemployment becomes especially severe if the afflicted plant is located in an area already suffering high unemployment, or that would suffer unemployment as a result of the plant's closing down. In such areas, new industrial employment may be very difficult to create, so that the closing of some plants has important implications for regional development. This is especially true where unemployed workers are reluctant to move in order to seek new jobs and, instead, remain both in the area and unemployed. If the plant's closing reduces income in one sector of the region's economy, a multiplier effect may cause a several-fold decrease in income generated in the region. Unemployed workers buy fewer goods and services from local people who in turn buy less from others and so on. Thus, income is reduced in the area beyond immediate losses to the workers directly involved.

Another impact on the region arises from the existence of economies of scale in many public services, for example, education. As regional income is reduced, population tends to decrease because jobs are unavailable. For those who remain, the average costs of public services like health and education rise because it costs more per person to provide such services to smaller groups of people. This reduces the well-being of the residents still further. Finally, once a region reaches a state of hard-core poverty, the investment required to restore it to acceptable standards is so large as to make rehabilitation difficult without a massive, systematic government program.

Consideration of these problems should make a decision-maker somewhat wary of a pollution abatement program which increases hard core unemployment in such areas. At the same time, the decision-maker must also be conscious of the fact that there is a difference between preventing unemployment and merely postponing it for a few years. In a situation where unemployment will occur eventually regardless of the choice of industrial assistance or incentives, the decision-maker should be cautious about obtaining a few more years of employment at a cost of significant inefficiency in pollution abatement.

Not only do workers suffer when a plant closes, but the owners too are subject to hardships. Although the unemployed worker is perhaps in a worse position than the owner, we cannot dismiss the losses incurred by the owner of a plant which is forced

to close. A person who owns part of a company which will have to close because of pollution abatement is being treated inequitably compared to someone who holds shares in a company not troubled by pollution abatement. When most current owners bought shares in current companies, the value of any pollution rights the company had — i.e. the value of waste disposal points where treatment was not undertaken — was reflected in the price they paid. This "right" is now being taken from them. This situation is especially relevant to plants which have been producing for a long time and have never been faced with water pollution problems. On the other hand, since he has been free from pollution abatement costs in the past, the owner of a hardship plant has been receiving greater profits than he would have had he provided for pollution abatement.

The cost to the owners of closing down includes both shutdown expenses and the foregone income from the use of his plant and equipment. Since the capital equipment is largely immobile, and is often already paid for, the firm owner has only to cover labor, overhead, and maintenance costs in order to stay in business. In such a situation the low opportunity costs may be one reason why some of these small plants are still in operation.

On the other side of the balance, there are reasons why we might want such hardship plants to close. If we assume that price reflects the benefits of a product to society, then, from society's point of view, those products which cost more than the benefits they offer should not be produced. It is precisely because potential hardship plants have costs greater than the price they receive that they will go out of business when forced to assume pollution abatement costs. Thus, it may be economically efficient for these firms to close. However, the argument that efficiency implies that these plants should close assumes that the prices of the inputs to the firm reflect the real opportunity costs of the resources involved. If, on the contrary, workers from the closed plants would remain unemployed, the real opportunity costs of producing the goods in question may be less than the nominal money cost.

There is one further benefit which would accrue to society if such firms closed: their pollution would be eliminated. This, after all, is the social goal that was the object to begin with.

On the basis of the above discussion it is possible to draw the following general conclusions as to what considerations ought to inform any policy in this area:

policy guidelines

A. The basic concern in the case of the hardship plants is the impact closing such a plant may have on its employees, and on the area in which it is located.

B. Policy makers should be most concerned about firms closing in depressed, or potentially impacted areas. Closing a small tannery in a big city with a high-demand labor market is less critical than closing the only mill in a small town in a rural area.

C. Since many so-called hardship cases will be plants that would have closed with or without pollution regulations, an effort should be made to avoid creating treatment facilities in all cases at no cost to the firm involved. The treatment capacity might become useless once failing plants actually closed.

D. In the long run, prices and production locations should shift so as to reflect the real costs to the society of producing in alternative locations. Thus in the long run it would be efficient for many of the hardship plants to close. The problems lie with the orderly transition of resources from the affected plants into other, more productive uses. Thus, the focus of any assistance program should be to facilitate this transition rather than permanently assume the costs of pollution control for some special segment of industry.

E. There are special cases, not discussed previously in this section, of firms which are quite sound in the long run but which have temporary difficulties, or do not have easy access to capital markets. It would be socially inefficient to force firms in this category to close plants because of the need to make an immediate investment in pollution control.

some administrative difficulties

Before we consider any specific programs to carry out the general guidelines stated above, it is necessary to consider the limitations placed on policy by the administrative and legal possibilities. The real meaning of the hardship case is a plant whose profitability would be seriously threatened by the need to undertake pollution abatement. This implies that the focus of interest is a plant whose abatement costs per unit of output are higher than the average of its competitors. If the market for the final products of the firm were especially competitive, the relevant comparison would be the difference between the hardship plant's costs of abatement per unit of output and such costs for the new or potential plant in the industry. The latter's low costs are the level at which prices are set by competitive forces.

But how are any of these notions to be embodied in a set of administratively feasible rules? One cannot formulate assistance programs by requiring all firms to predict their profitability over the next 5 to 10 years. Neither the dollar costs of pollution expenditure, nor such dollar costs divided by the net value of a plant's output are really relevant. If costs are high for all plants in some segment of an industry that has no close competitors, no special hardships devolve on any particular plant. In some cases no doubt, like multi-plant firms, the theoretically desirable information may not even be available for current profits. Not all the concerns in question will have bookkeeping techniques that allow one to look at the results of each of their plants separately. Therefore, creating any actual system of assistance must represent a compromise between the theoretical concepts discussed earlier and the limitations on their implementation implied by the nature of the real world, specifically its uncertainty and the unavailability of certain kinds of information.

conclusions and recommendations

A. Since the most serious problem produced by hardship cases is unemployment, the policies needed most are those that deal directly with this dimension of the situation. Since it is so difficult in practice to define what firms we are interested in assisting, or to know which of those would have remained in business without the burden of pollution control expenditure, there is much to be said for trying to deal with the impact of any plant shut-down through existing programs for regional redevelopment and job retraining. Perhaps some definition of a "pollution-control impacted area" could be incorporated into these other pieces of legislation, making such areas eligible for special assistance.

B. Where possible, connecting a hardship plant into an existing municipal treatment system, or into the water quality program of a regional water quality authority offers one of the best solutions to the problem. In such cases, firms are not penalized by their small size and instead pay the average cost of the central authority, which has all the advantages of the economies of scale and manipulation of river hydrology. Further, large treatment systems would not have to be especially concerned with the excess capacity that would result when a failing firm eventually closed. General population and industrial growth could be expected to utilize that capacity in a reasonable time period. Also, one of the chief burdens on hardship cases is the problem of raising the capital to construct treatment facilities. Being tied into a central system obviates this need. However, many of the firms we are interested in are located in rural areas and would not be able to connect with existing municipal systems. This is one more argument for the establishment of a regional water quality authority which could effectively handle these cases.

C. When it comes to giving assistance directly to hardship cases, we are faced immediately with the problem of defining these cases. Ideally we want firms whose abatement costs per unit of production are above the industry average. To require a showing on this basis would impose significant administrative costs on the firm — costs that might discourage just those plants who need assistance most from applying. We can isolate potential hardship cases by limiting assistance to plants significantly smaller than the median size for their industry that are located in depressed areas, areas of locally high unemployment, or areas that would have high local unemployment if the plant closed.

The core problem for some hardship cases, especially those that might be viable in the long run, is the availability of capital to construct treatment facilities. However, where the affected plant is owned by a large multi-plant company, the crux of the difficulty is that the costs of abatement will render the plant no longer profitable.

There are two forms of direct assistance to hardship plants which might be considered:

i. Hardship plants could be allowed several years extra grace in complying with water quality standards. This would make it easier for long-run profitable concerns who happen to be in short term difficulties to comply. Where plants cannot be profitably operated in the long run in any case, some will die their natural death in the grace period, and others will be given sufficient time to cease business in an orderly manner. Paying for the operation of these plants for a few years by accepting the costs imposed on society by their pollution seems less expensive than constructing long-lived treatment facilities which would become idle in a few years if the plant failed. This may not be a serious cost. The optimal pollution abatement program for a river basin might not even include waste treatment for some of these firms because of their small size and isolation (see Regional Water Quality Agencies above).

ii. Special low interest loans might be made available to small plants in depressed or potentially depressed areas. Such aid would allow genuinely viable operations to avoid the major difficulty of pollution control expenditure: the need to raise additional burdens to the firm that would come with such assistance, and so would tend to stay out of the program. This would minimize the amount of ultimately idle treatment capacity that the program would produce. It is reasonable to restrict the loans to small firms even though some marginal or failing plants are owned by large companies. Such companies do not face the same difficulties in capital markets as small concerns; this form of assistance is not really relevant to their needs.

It is wise to remember that the logic of long run economic efficiency implies that plants which cannot meet their abatement costs are costing society more than they are producing. Hence such plants ought to close in the long run. It is only the impact on workers and on regional development that makes policy in this area appropriate in any case. The only justification for compensating owners of plants that choose to close rather than clean up is the implicit assumption that they have a property right in their current pollution practices, a proposition which national policy makers have repeatedly denied. If the stream standards are set fairly, the social costs of pollution are high enough to justify the costs of abatement. Any transitional period is difficult, but that is the price society pays for having waited so long to become concerned about the quality of its water.

¹ In discussing the value of the output of a firm, the appropriate technical concept is "value added," the amount a firm sells minus the value of its purchases. The difference is an indicator of how much the firm actually contributes to the national product.



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